LIMITED ENERGY STUDIES
FORT RUCKER, ALABAMA

CONTRACT NUMBER DACA01-92-C-0119

PREPARED FOR:
MOBILE DISTRICT
U.S. ARMY CORPS OF ENGINEERS
MOBILE, ALABAMA

PREPARED BY:
ENGINEERING RESOURCE GROUP, INC.
P.O. BOX 360687
BIRMINGHAM, ALABAMA 35236
205/985-9090

MARCH 1993

P.O. BOX 9005
CHAMPAIGN, ILLINOIS 61826-9005

REPLY TO
ATTENTION OF: TR-I Library

17 Sep 1997

Based on SOW, these Energy Studies are unclassified/unlimited. Distribution A. Approved for public release.

Marie Wakefield,
Librarian Engineering

TABLE OF CONTENTS

TABLE OF CONTENTS

TABLE OF CONTENTS

1.0 INTRODUCTION AND PROJECT OVERVIEW

In August of 1992, Engineering Resource Group, Inc., was retained by the Mobile District U.S. Army Corps of Engineers to perform Limited Energy Studies at Fort Rucker, Alabama. These studies were to address specific projects at Fort Rucker and at the Lyster Army Community Hospital on base that had potential to reduce energy costs through energy demand control or energy conservation. This report summarizes results from the investigations made by Engineering Resource Group and their consultant into the specific projects defined by the Contract Scope Of Work.

1.1 Scope Of Work

There are two main areas of work addressed under this contract, an LP gas storage study for Fort Rucker and the evaluation of two energy conservation opportunities for Lyster Army Community Hospital.

1.1.1 LP Gas Storage:

The objective of this project was to evaluate the technical and economic feasibility of building and operating a liquified petroleum gas (LPG) storage facility at Fort Rucker. The primary heating fuel at Fort Rucker is natural gas; it is used in central steam plants and in central forced-air furnaces for family housing. Natural gas is purchased from the Southeast Alabama Gas District at their lowest rate. However, Fort Rucker also pays a natural gas demand charge based on the amount of natural gas used during curtailment. During a curtailment period, the natural gas demand is intended to be reduced as much as possible by switching the central steam plants to oil; but the family housing area continues to use natural gas. An LPG storage system would provide the capability of injecting a mixture of air and propane into the natural gas distribution system during curtailment to reduce natural gas demand. This would result in lower gas bills throughout the year.

1.1.2 Lyster Army Community Hospital

An Energy Engineering Analysis Program study was completed for Lyster Army Community Hospital in 1989. The following two projects address one additional project not included in the original EEAP study and a reevaluation of one that had been included. Further analysis is to determine the interrelationship of these two projects.

1.1.2.1 Cooling Storage System For Peak Demand Reduction

The objective of this project was to evaluate the technical and economic feasibility of reducing peak electrical demand at the hospital by use of a cooling storage system. This study will determine the optimum type of cooling storage system for the hospital. Accurate evaluation of this project required the modeling of building thermal loads with an approved computer simulation program such as Trane TRACE.

1.1.2.2 Chiller Heat Recovery For Domestic Hot Water

The objective of this project was to evaluate the technical and economic feasibility of recovering heat from the hospital chillers for preheating domestic hot water with and without the cooling storage system mentioned above. Heat recovery from chillers was recommended in the 1989 study but has not been implemented.

1.2 Description Of Work

In order to completely address all of the considerations required to properly evaluate the projects defined in the Scope Of Work, the following procedures were to be followed in accordance with the contract.

1. Review the previously completed energy studies which apply to the buildings, systems, or energy conservation opportunities (ECOs) covered by this study.
2. Perform a limited site survey of specific buildings or areas to collect all data required to evaluate the specific ECOs included in this study.
3. Reevaluate the specific project or ECO from the previous study to determine its economic feasibility based on revised criteria, current site conditions and technical applicability.
4. Evaluate specific ECOs to determine their energy savings potential and economic feasibility.
5. Provide project documentation for recommended ECOs as detailed herein.
6. Prepare a comprehensive report to document all work performed, the results and all recommendations.

1.3 Criteria And Methodology

Criteria utilized to reach the conclusions established in this study are as follows. Where appropriate, this information in whole or part is included as part of the appendices.

1. "Engineering and Design Energy Conservation", Department of the Army, Office of the Chief of Engineers, Washington, D. C., 20314, ETL 1110-3-282, dated 10 February 1978.

2. "Energy Conservation Investment Program (ECIP) Guidance", memorandum CEHSC-FU-M dated 23 November 1991 and revisions dated 28 June 1991 and 4 November 1992.

3. "Military Construction, Army (MCA) Program Development", Headquarters Department of the Army, Washington , D. C., Army Regulation 415-15, effective 1 January 1984.

4. "Facilities Engineering Energy Storage Systems, Lessons From Field Demonstration And Testing Of Storage Cooling Systems", Department of the Army, U. S. Army Engineering and Housing Support Center, Fort Belvoir, VA, 22060-5516, Technical Note No. 5-670-1, dated 16 April 1992.

5. The Southeast Alabama Gas District Billing History, Fort Rucker.

6. Alabama Power Company Revision No. 8 - Rate Schedule MR-1.

7. Alabama Power Company Customer Data Sheet, Year 1992, U. S. Army Aviation Center, Ft. Rucker.

8. Alabama Power Company KW/KVA/KVAR Power Factor Summary, U. S. Army Aviation Center.

9. 1989 Energy Survey, Lyster Army Community Hospital, Fort Rucker, Alabama, U. S. Army Corps of Engineers Mobile District, Contract Number DACA01-87-C-0084, Energy Management Consultants, Inc., Birmingham, Alabama.

10. ASHRAE Handbooks: "1987 HVAC Handbook, Systems and Applications", American Society of Heating Refrigerating and Air Conditioning Engineers, Inc.

11. "Means Mechanical Cost Data", 1993 Edition.

12. "Investigation Report And Draft Acquisition Plan", Exeter Associates, Inc., Contract Number DACA72-88-D-0005, dated June 1989.

13. "Seminar Notes: Thermal Energy Storage Systems", Mackie Associates, November 1992.

14. "Case Studies Of Chilled Water Storage", John S. Andrepont, Product Manager, Thermal Systems, Chicago Bridge & Iron Co., 1993.

15. "Case Study Of A Large, Naturally Stratified, Chilled-Water Thermal Energy Storage System", Donald P. Fiorino, P.E., Member ASHRAE, IN-91-20-2.

16. "Thermal Energy Storage Program For The 1990s", Donald P. Fiorino, P.E., Texas Instruments, Inc., Vol. 89, No. 4, 1992.

17. "How To Put A Chill On Rising Energy Costs", NATGUN, 1991.

18. "Stratified Chilled-Water Storage Design Guide", Electric Power Research Institute (EPRI), May 1988.

Methodology to evaluate the LP Gas Storage system included a comprehensive review of gas bills from Southeast Alabama Gas District, applicable gas rates and the report prepared by Exeter Associates, Inc., listed above in the criteria utilized list.

Methodology to determine cooling load profiles at Lyster Army Community Hospital included the utilization of Trane TRACE to model the facility. Input data from the original 1989 EEAP Study was retrieved, verified, and a new input model was developed for the specific purpose of evaluating cooling storage. This data was then used to perform manual simulations to determine the impact of cooling storage at the hospital on the base electrical meter.

1.4 Organization

An entry interview was held at Lyster Army Community Hospital on September 9, 1992, to review the project objectives and discuss each participants role and procedures for execution. All parties listed below with the exception of Ms. Winnett were present. Field visits were made by Mr. Jackins and Mr. Guthrie during October, November and December 1992. Evaluations and analysis of the selected projects were done during January and February 1993. The report has been written in March 1993 for the Interim Submittal to be made by 31 March 1993. The project is to be completed by 15 May 1993.

The principal participants in the preparation of this study are:

For The Owner: U. S. Army
Mr. Tony Battaglia
Mobile District U. S. Army Corps Of Engineers

Mr. Bill DeJournett, Energy Manager, DEH
Fort Rucker, Alabama

Mr. Alan Plant, Facility Manager, EMCS
Lyster Army Community Hospital
Fort Rucker, Alabama

For The Contractor: Engineering Resource Group, Inc.
Mr. George A. Jackins, P.E.
Project Manager

Mr. Boyce Guthrie, P.E.
L.P. Gas Peak Shaving Consultant

Ms. Kelly L. Winnett
Project Engineer

2.0 EXECUTIVE SUMMARY

In August of 1992, Engineering Resource Group, Inc., of Birmingham, Alabama was retained by the Mobile District U. S. Army Corps of Engineers to perform Limited Energy Studies at Fort Rucker, Alabama. These studies were limited to the evaluation of specific projects that have potential to reduce energy costs through energy demand control or conservation. These projects are:

1. LP Gas Storage: Evaluate the technical and economic feasibility of building and operating a liquified petroleum gas (LPG) storage facility at Fort Rucker to reduce natural gas demand charges.

2. Cooling Storage System For Peak Demand Reduction: Evaluate the technical and economic feasibility of reducing peak electrical demand at Lyster Army Community Hospital by the use of a cooling storage system.

3. Chiller Heat Recovery For Domestic Hot Water: Evaluate the technical and economic feasibility of recovering heat from the hospital chillers for preheating domestic hot water at Lyster Army Community Hospital.

Each project is summarized individually in the following discussions.

LP Gas Storage

During the twelve month period from September 1991 to August 1992, Fort Rucker paid the Southeast Alabama Gas District a total of $2,019,981.50 for the delivery of natural gas to the base. This natural gas was used to fire boilers in five central steam plants and to heat family housing. Of this total cost, $491,647.22 or 24% was demand charges. The demand charges each month is established by the highest daily usage during a period of curtailment. On January 16, 1992, when the base was on curtailment, the daily usage was recorded at 3,436 MCF which set the basis for demand charges for the following eleven months. If this one day demand could have been reduced, it would have resulted in a lower delivered natural gas cost for the rest of the year.

One method of reducing this peak daily usage during a period of curtailment is to switch the dual fuel boilers in the central steam plants from natural gas to oil. The investigations conducted in this study indicated, however, that this was not done during the January 1992 period of curtailment. Assuming that there was good reason for not switching to oil during that period, this study examines the use of an appropriately sized LP Gas Peak Shaving plant as the only means of reducing demand during curtailment and evaluates the added benefit of switching from natural gas to oil in the central steam plants.

The economics of utilizing various sizes of LP Gas Peak Shaving plants are examined in this study. Considering good practice in the design and operation of such plants coupled with the added benefits of fuel switching in the central steam plants, a capacity of 1,500 MCF per day was selected for the proposed LP Gas Peak Shaving plant.

Annual Savings, MCF Demand	-	1,500
Annual Cost Savings	-	\$200,794
Total Investment	-	\$970,050
Simple Payback	-	4.83 Years
Total Net Discounted Savings	-	\$4,136,356
Savings To Investment Ratio (SIR)	-	4.26
Adjusted Internal Rate Of Return (AIRR)	-	12.00%

Cooling Storage System For Peak Demand Reduction

Lyster Army Community Hospital, Building 301 located at Fort Rucker, Alabama is a 72 bed total health care facility with a gross area of 206,720 square feet. It is presently cooled by a chilled water plant in the building utilizing three centrifugal chillers with a total capacity of 820 tons. These chillers are currently manually staged by operating personnel to meet building cooling loads.

A comprehensive Energy Engineering Analysis Program (EEAP) was performed at Lyster Army Community Hospital in 1989. The results of this program were available to facilitate the appropriate direction of the Limited Energy Studies evaluated under this contract. One of the Energy Conservation Opportunities (ECO 2) defined in the 1989 study has a significant impact on the ease of implementation of a Cooling Storage System. This ECO provides for the installation of primary-secondary chilled water loops with variable speed pumping in the secondary loop. Base personnel advised that this ECO has been selected for implementation and engineering has been done. The project implementation is now predicated on funding. This project to study a Cooling Storage System for Peak Demand Reduction has been developed assuming that ECO 2 from the 1989 study will be implemented.

An analysis of the 24 hour electrical load profile of the hospital during a peak summer day indicates a relatively level load. This, plus the fact that there are no specific incentives in the electric rate applicable to the base such as off peak demand cost reduction, would indicate that little potential existed for load shifting for demand reduction.

However, an examination of the same profile for the entire base reveals a significant swing from on peak loads to off peak loads. This swing on a peak summer day is as much as 15,000 KVA, more than enough to absorb the off peak use of the remaining unused capacity of the hospital chillers for storage. Utilizing Trane TRACE 24 hour cooling load profiles of the hospital, a strategy was developed to store adequate chilled water during off peak hours to meet the total cooling requirements of the hospital during the on peak six hour period the next day. This strategy results in a reduction of monthly demands at the base electric meter for 8 of the 12 months due to the 75% demand ratchet applicable to the peak summer month.

Annual Savings, KVA Demand	-	3,093.6
Annual Cost Savings	-	$47,964
Total Investment	-	$338,824
Simple Payback	-	7.06 Years
Total Net Discounted Savings	-	$651,831
Savings To Investment Ratio (SIR)	-	1.92
Adjusted Internal Rate Of Return (AIRR)	-	7.45%

Chiller Heat Recovery For Domestic Hot Water

The Energy Engineering Analysis Program (EEAP) performed at Lyster Army Community Hospital in 1989 identified and recommended and ECO to utilize waste heat from one centrifugal chiller to preheat domestic hot water. This ECO is reevaluated in this study based on current implementation and energy costs. Additionally, an analysis has been performed of the impact of the selected chilled water storage strategy on this ECO.

Based on a review of the original estimate to implement the chiller heat recovery ECO, it was found that this estimated cost increased from $21,870 to $27,820. At the same time energy costs reduced from those used in the original ECO as follows:

Electrical Energy: From $0.043993/KWH To $0.0215/KWH

Natural Gas: From $0.411/Therm To $0.289/Therm

It was established that the methodology and estimates made of energy savings in the original ECO were reasonable and would be used in this reevaluation. The economics of the project change significantly as follows.

Annual Energy Savings:		
Electric	-	139.56 MBTU/Year
Natural Gas	-	963.60 MBTU/Year
Total	-	1,103.16 MBTU/Year
Annual Cost Savings:		
Electric	-	$879
Natural Gas	-	$2,785
Total	-	$3,664
Total Investment	-	$31,019
Simple Payback	-	8.47
Total Net Discounted Savings	-	$70,248
Savings To Investment Ratio (SIR)	-	2.26
Adjusted Internal Rate Of Return (AIRR)	-	8.00%

The revised economics for this ECO make its desirability for implementation questionable. It must be combined with other projects to be considered as an ECIP project.

As part of this ECO, further analysis was performed to determine the impact of the proposed cooling storage strategy on the heat recovery capability of the centrifugal chiller. Based on Trane TRACE projections of ton-hours produced by the chiller before and after, there was a projected reduction of chiller operating time of 36%. This reduction impacted the estimated energy savings and costs by the same amount. The resulting payback of the heat recovery ECO if combined with the cooling storage ECO is 11.85 years making this ECO not recommended if the cooling storage ECO is implemented.

3.0 ENERGY CONSERVATION OPPORTUNITY: LP GAS STORAGE

The purpose of this study is to determine the economic and technical feasibility of a propane-air peak shaving facility to reduce overall natural gas cost by reducing the monthly demand charge for natural gas.

The calculations for savings use the actual billing figures (see Table 3.1) for natural gas from September 1991 through August 1992 demonstrating what savings would have occurred if a propane-air peak shaving plant were used to reduce demand of natural gas. For purposes of this study propane cost is assumed at $0.50 per gallon. Lower propane prices are possible during the months of low propane demand.

3.1 Existing Conditions

Ft. Rucker purchases natural gas from Southeast Alabama Gas District under contract No. DA-01-044-A111-278 that bills a commodity charge plus a demand charge. Southeast Alabama Gas District purchases gas from Southern Natural Gas Company, an interstate pipeline Company, then adds a margin for billing to Ft. Rucker under rate schedule OCD-2. The commodity margin is $0.17307 per MCF and the demand margin is $0.5903 per MCF per the contract. An adjustment to convert from volumetric to thermal basis is added to the commodity charge. The demand charge per month is determined by the highest daily usage during the year.

Some information for this study was obtained from "Investigation Report and Draft Acquisition Plan" prepared under contract No. DACA72-88-D-0005 by Exeter Associates, Inc. in June 1989. The results of that report found that Ft. Rucker, at the present time, cannot participate in direct purchase and transportation of natural gas because Southeast Alabama Gas District does not offer transportation services. The Exeter study suggests that Ft. Rucker continue negotiations with Southeast Alabama Gas District for direct purchase and transportation.

During the 12 month period from September 1991 to August 1992, the lowest commodity charge of $2.3678 per MCF occurred in September 1992 and the highest commodity charge of $3.0357 per MCF occurred in December 1992. The demand charge has a low of $8.9520 per MCF in June 1992 and a high of $21.5123 per MCF in February and March 1992. See Table 3.1. The lowest daily usage of 594 MCF occurred on August 5, 1992 and the highest daily usage of 3,436 MCF occurred on January 16, 1992. Ft. Rucker gas supply was on curtailment from January 15 to January 22, 1992. The monthly demand charge for 1991 was established on January 15, 1991, at 3,234 MCF per day. The monthly demand charge for 1992 was established on January 16, 1992 at 3,436 MCF per day.

3.1.1 Steam Heating Plants

Ft. Rucker has five dual fuel (natural gas and No. 2 fuel oil) steam heating plants located throughout the facility. This study can find no evidence that the boilers were switched to fuel oil at any time during the period from October 1991 to September 1992. The demand of 3,436 MCF per day established on January 16, 1992, could have been reduced by approximately 1,000 MCF per day to 2,436 MCF per day if the boilers had been switched to No. 2 fuel oil. The 1,000 MCF per day reduction is based on the Exeter Study, page I-4, Par. 2 which stated, "Ft. Rucker personnel estimated these boilers would add a load of 1,000 MCF per day during peak periods."

3.1.2 Total Natural Gas Use And Cost

The total natural gas usage from September 1992 to August 1992 was 528,600 MCF at a total cost of $2,019,981.40. The demand portion was $491,647.22 and the commodity portion with BTU adjustment was $1,528,334.30. Refer to Table 3.1. This study will focus on reducing the demand cost with a propane-air peak shaving plant.

TABLE 3.1: NATURAL GAS USAGE AND COST (SEPTEMBER 1991 TO AUGUST 1992)

MONTH	GAS USAGE (MCF)	COST PER MCF ($)	COMM. COST ($)	BTU ADJUST. (%)	BTU ADJUST. COST ($)	COMM. & ADJUST. COST ($)	DEMAND 1/15/91 (MCF)	DEMAND CHARGE PER MCF ($)	DEMAND COST ($)	TOTAL COST ($)
SEP 91	27,577	2.36786	65,298.48	2.080	1,358.21	66,656.69	3,234	9.4783	30,652.82	97,309.51
OCT 91	29,736	2.86565	85,212.97	2.060	1,755.39	86,968.36	3,234	9.0253	29,187.82	116,156.18
NOV 91	63,882	2.86565	183,063.45	2.110	3,862.64	186,926.09	3,234	9.0253	29,187.82	216,113.91
DEC 91	65,952	3.03576	200,214.44	2.220	4,444.76	204,659.20	3,234	21.4683	69,428.48	274,087.68
(NEW DEMAND SET ON JANUARY 16, 1992 AT 3,436 MCF)										
JAN 92	78,717	2.99800	235,993.57	2.210	5,215.46	241,209.03	3,436	21.5123	73,916.26	315,125.29
FEB 92	60,902	2.84832	173,468.38	2.110	3,660.18	177,128.56	3,436	21.5123	73,916.26	251,044.82
MAR 92	52,023	2.78237	144,747.23	2.070	2,996.27	147,743.50	3,436	9.0693	31,162.11	178,905.61
APR 92	33,361	2.55612	85,274.72	2.030	1,737.05	87,011.77	3,436	8.9523	30,760.10	117,771.87
MAY 92	30,379	2.65504	80,657.46	2.177	1,755.91	82,413.37	3,436	8.9523	30,760.10	113,173.47
JUN 92	29,638	2.69185	79,781.05	2.190	1,747.20	81,528.25	3,436	8.9523	30,760.10	112,288.35
JUL 92	28,291	2.92832	82,845.10	2.226	1,844.13	84,689.23	3,436	9.0113	30,962.83	115,652.06
AUG 92	28,142	2.82470	79,492.71	2.400	1,907.83	81,400.54	3,436	9.0083	30,952.52	112,353.06
TOTALS	528,600	2.89129	1,496,649.40		32,285.03	1,528,334.30			491,647.22	2,019,981.50

3.2 Size And Demand Considerations

This study analyzed four different sizes of peak shaving systems: 1,000 MCF per day, 1,500 MCF per day, 2,000 MCF per day and 2,500 MCF per day. See Table 3.2. A life cycle cost analysis, included in Section 3.4, indicates the optimum economical size at 2,000 MCF per day. Reducing the demand by 2,000 MCF per day yields a net annual savings of $251,096.54. A 1,500 MCF per day reduction in demand yields a net annual savings of $188,322.40. These savings are based on reducing demand with a propane-air peak shaving system operating during curtailment and the heating boilers remaining on natural gas. Additional reduction in demand is available with boilers switched to fuel oil.

While life cycle costing favors a 2,000 MCF per day plant, technical considerations concerning the ratio of propane-air flow to natural gas flow and switching the boilers to fuel oil during curtailment dictate a 1,500 MCF per day plant. The mixture of propane-air flow in relation to natural gas flow is not governed by codes or law, however it is considered good practice to keep equivalent propane-air flow at less than 50% of natural gas flow; particularly if any burners supplied by the system do not have 100% safety shut-off. With a demand of 3,436 MCF per day (January 16, 1992) and a propane-air system size of 2,000 MCF per day the propane-air flow will exceed 50% of natural gas flow at full load even with boilers using natural gas.

Please note that the demand of 3,436 MCF per day was established with the heating boilers using natural gas. If the boilers had been switched to fuel oil during curtailment the demand could have been reduced by approximately 1,000 MCF per day to 2,436 MCF per day without a propane-air system. This is based on the Exeter study Par. 2, Page I-4 which stated, "Ft. Rucker personnel estimated these boilers would add a load of 1,000 MCF per day during peak periods."

A 1,500 MCF per day plant would exceed 50% of 2,436 MCF per day. However, the 1,000 MCF per day demand reduction available by switching the boilers to fuel oil is only an estimate, and the possibility of one boiler having problems with fuel oil exists. Therefore, a 1,500 MCF per day plant provides reserve as well as flexibility with operations.

3.3 LP Gas Storage Plant

In the previous section we state that life cycle costing favors a 2,000 MCF per day plant, however technical considerations concerning mixture of propane-air and natural gas and switching the heating boilers to oil during curtailment dictate a 1,500 MCF per day plant.

The net savings of a 1,500 MCF per day plant with heating boilers using natural gas would have been $188,322.40. See Table 3.2.

The net savings calculations for reduction of demand charges would apply for any method of reducing demand. If the boilers had been switched to fuel oil during January 15-22, 1992, and the estimate of 1,000 MCF per day reduction in demand noted in the Exeter report is correct, the savings would have been approximately $120,000 for 1992 without a propane-air peak shaving system.

A new 1,500 MCF per day plant in addition to switching the five heating boilers to oil would have reduced the demand to 1,218 MCF per day (50% of 2,436 MCF per day) on January 16, 1992, producing a demand savings of approximately $323,733.27. The estimated cost difference between natural gas and a combination of propane/fuel oil is $50,000.00 during curtailment, for an estimated net savings of $273,733.27.

This study recommends the installation of a 1,500 MCF per day propane-air peak shaving system and diligence in switching boilers to fuel oil during curtailment.

3.3.1 Plant Description

The propane-air peak shaving system should have a minimum of five 30,000 gallon storage tanks (7.5 days storage), a high capacity truck unload station, a duplex liquid pumping system with controls, vaporizer, mixer with control package, two 50 hp air compressors, flow control package and building.

The injection point of propane-air into the natural gas line should be just downstream of the natural gas meter and before any branch take-offs of the Ft. Rucker natural gas distribution system. Backfeeding is not recommended because of small line sizes and lack of good mixing of propane-air and natural gas.

A review of plot plan drawings and field inspection dictates only one site suitable for location of the propane-air system. NFPA #58 and 59 codes and good engineering practice dictate distances from storage tanks, vaporizers, mixers and unloading stations from each other and from buildings, property lines, power lines, etc. The only site available is the vacant field across the main entrance road from the natural gas meter station. This vacant field is across the parking area from buildings 1098 and 2098. See Figure 3.1.

This location has been discussed with Ft. Rucker long range planning and does not interfere with future plans.

3.3.2 Cost Of Plant

The following is a breakdown of estimated cost of a 1,500 MCF per day plant.

COST ESTIMATE ANALYSIS
For use of this form, see TM 5-800-2; the proponent agency is USACE.

PROJECT	PROPANE - AIR PEAK SHAVING SYSTEM
LOCATION	LYSTER ARMY COMMUNITY HOSPITAL
INVITATION/CONTRACTOR	
CODE (Check one)	☐ A ☐ B ☐ C ☐ OTHER
EFFECTIVE PRICING DATE	3/93
DRAWING NO.	
ESTIMATOR	
DATE PREPARED	
SHEET	1 OF 2 SHEETS
CHECKED BY	

TASK DESCRIPTION	QUANTITY		LABOR				EQUIPMENT		MATERIAL		TOTAL	SHIPPING	
	NO. OF UNITS	UNIT MEAS	MH UNIT	TOTAL HRS	UNIT PRICE	COST	UNIT PRICE	COST	UNIT PRICE	COST		UNIT WT	TOTAL WT
30,000 GALLON													
PROPANE TANKS													
AND TRIM	5	EACH			10,000	50,000			65,000	325,000	375,000		
TRUCK TRANSPORT													
UNLOAD STATION	1	JOB			9,500	9,500			8,500	8,500	18,000		
DUPLEX LIQUID													
PUMPING SYSTEM	1	JOB			4,000	4,000			13,000	13,000	17,000		
VAPORIZER / MIXER													
UNIT	1	JOB			30,000	30,000			150,000	150,000	180,000		
(CONTINUED)													
TOTAL THIS SHEET													

DA FORM 5418-R, Apr 85

COST ESTIMATE ANALYSIS
For use of this form, see TM 5-800-2; the proponent agency is USACE.

PROJECT: PROPANE - AIR PEAK SHAVING SYSTEM	INVITATION/CONTRACTOR	EFFECTIVE PRICING DATE: 3/93	DATE PREPARED
LOCATION: LYSTER ARMY COMMUNITY HOSPITAL	CODE (Check one) ☐ A ☐ B ☐ C ☐ OTHER	DRAWING NO.	SHEET 2 OF 2 SHEETS
		ESTIMATOR	CHECKED BY

TASK DESCRIPTION	QUANTITY		LABOR				EQUIPMENT		MATERIAL		TOTAL	SHIPPING	
	NO. OF UNITS	UNIT MEAS	MH UNIT	TOTAL HRS	UNIT PRICE	COST	UNIT PRICE	COST	UNIT PRICE	COST		UNIT WT	TOTAL WT
DUAL AIR COMPRESSOR													
SYSTEM	1	JOB			40,000	40,000			80,000	80,000	120,000		
PEAK SHAVING CONTROLS	1	JOB			15,000	15,000			80,000	80,000	95,000		
BUILDING	1	JOB			20,000	20,000			45,000	45,000	65,000		
NOTE: SITE WORK													
INCLUDED IN ITEMS													
1, 2, 3 AND 7													
TOTAL THIS SHEET											870,000		

DA FORM 5418-R, Apr 85

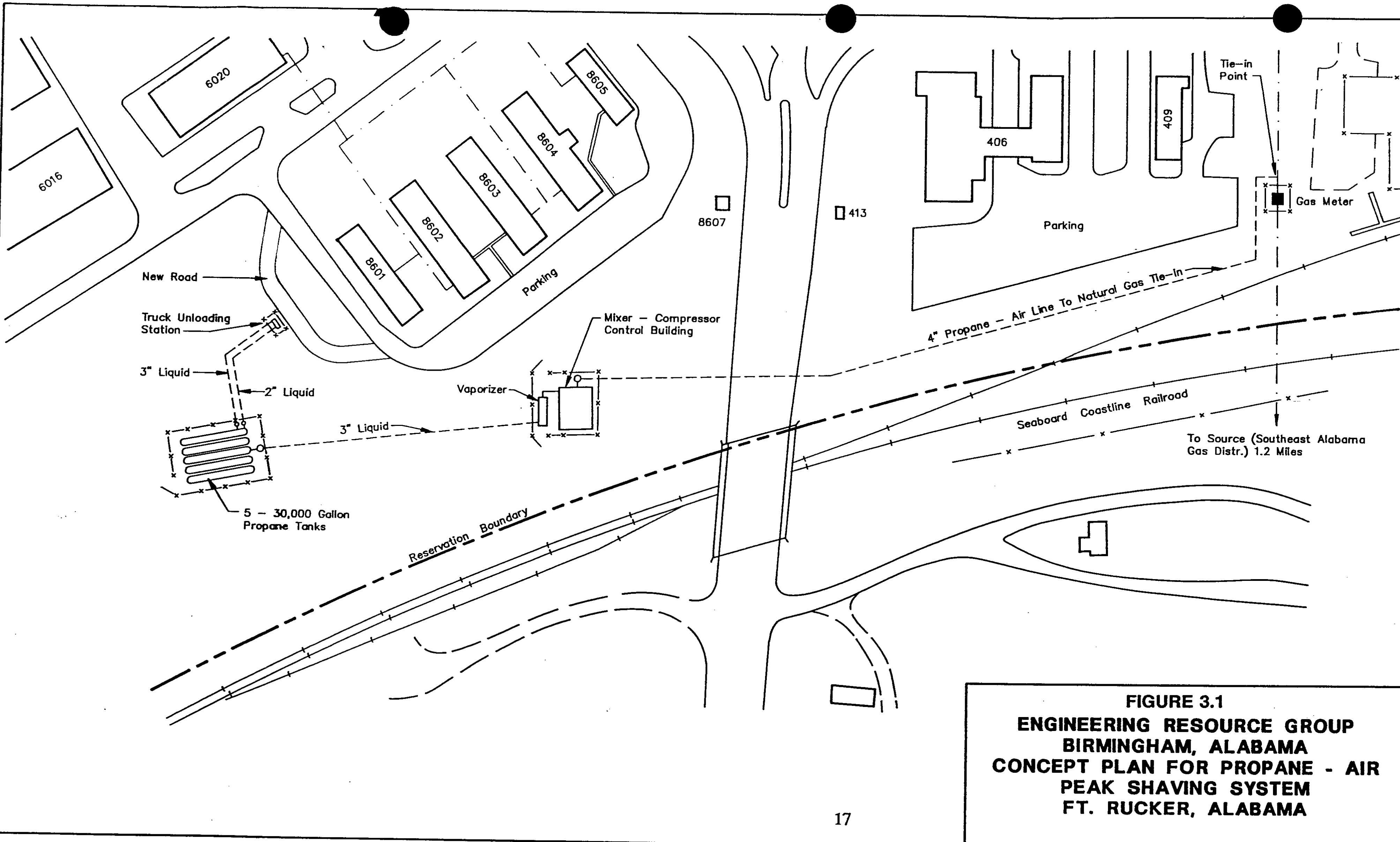


FIGURE 3.1
ENGINEERING RESOURCE GROUP
BIRMINGHAM, ALABAMA
CONCEPT PLAN FOR PROPANE - AIR PEAK SHAVING SYSTEM
FT. RUCKER, ALABAMA

3.3.3 Projected Savings

Calculations based on 1,500 MCF per day peak shaving system, boilers using natural gas and on the following information:

Natural Gas Replaced Per Day	1,500 MCF
BTU Value Natural Gas Jan. 1992	1,022 BTU/ft^3
Commodity Cost Natural Gas Jan. 1992	$2.998/MCF
BTU Adjustment Jan. 1992	2.21%
BTU Value Propane/Gallon	91,000 BTU/Gal
Propane Cost/Gallon	$0.50/Gal
Duration of Curtailment (Jan. 15-22, 1992)	8 days

Gallons of propane required for 8 day curtailment:

(1,500,000 ft^3/day X 1,022 BTU/ft^3 X 8 days)/91,000 BTU/Gal propane = 134,769 Gallons

Cost of 8 day supply of propane:

$0.50/Gal X 134,769 Gallons	=	$67,384.62

Commodity savings at 1,500 MCF per day for 8 days:

1,500 MCF/day X 8 days X $2.998/MCF	=	$35,976.00
Plus BTU Adjustment of 2.21%	=	795.07
Commodity Savings	=	$36,771.07

Cost Increase To Use Propane During Curtailment:

$67,384.62 - $36,771.07	=	$30,613.55

Demand Savings at 1,500 MCF per day:

See Table 3.2	=	$218,935.95
Less Cost Increase To Use Propane	=	30,613.55
Net Annual Savings	=	$188,322.40

Simple Payback:

Estimated Cost 1,500 MCF per day plant	=	$870,000.00
$870,000.00 / $188,328.51	=	4.62 years

TABLE 3.2: COST AND SAVINGS FOR VARIOUS SIZES OF PROPANE-AIR PEAK SHAVING SYSTEMS

		SIZE OF PEAK SHAVING SYSTEM			
MONTH/YEAR	DEMAND COST PER MCF	SAVINGS AT 1,000 MCF/DAY	SAVINGS AT 1,500 MCF/DAY	SAVINGS AT 2,000 MCF/DAY	SAVINGS AT 2,500 MCF/DAY
SEP 1991	$9.4783	$9,478.30	$14,217.45	$18,956.60	$23,695.75
OCT 1991	$9.0253	$9,025.30	$13,537.95	$18,050.60	$22,563.25
NOV 1991	$9.0253	$9,025.30	$13,537.95	$18,050.60	$22,563.25
DEC 1991	$21.4683	$21,468.30	$32,202.45	$42,936.60	$53,670.75
JAN 1992	$21.5123	$21,512.30	$32,268.45	$43,024.60	$53,780.75
FEB 1992	$21.5123	$21,512.30	$32,268.45	$43,024.60	$53,780.75
MAR 1992	$9.0693	$9,069.30	$13,603.95	$18,138.60	$22,673.25
APR 1992	$8.9523	$8,952.30	$13,428.45	$17,904.60	$22,380.75
MAY 1992	$8.9520	$8,952.00	$13,428.00	$17,904.00	$22,380.00
JUN 1992	$8.9523	$8,952.30	$13,428.45	$17,904.60	$22,380.75
JUL 1992	$9.0013	$9,001.30	$13,501.95	$18,002.60	$22,503.25
AUG 1992	$9.0083	$9,008.30	$13,512.45	$18,016.60	$22,520.75
ANNUAL DEMAND SAVINGS		$145,957.30	$218,935.95	$291,914.60	$364,893.25
Gallons Of Propane Per Day		11,231	16,846	22,462	28,077
Propane Cost At $0.50/gal/day		$5,615.50	$8,423.00	$11,231.00	$14,038.50
8 Day Interruption Cost For Propane		$44,923.08	$67,384.62	$89,846.15	$112,307.69
Commodity Savings For 8 Days With 2.21% BTU Adjustment		$24,514.05	$36,771.07	$49,028.09	$61,285.12
Cost Increase To Use Propane During Curtailment		$20,409.03	$30,613.55	$40,818.06	$51,022.57
Natural Gas Savings (Net)		$125,548.27	$188,322.40	$251,096.54	$313,870.68
Estimated System Cost		$715,000.00	$870,000.00	$1,050,000.00	$1,350,000.00
Simple Payback		5.70 Years	4.62 Years	4.18 Years	4.30 Years

Note: Heating boilers were not switched to oil during eight day curtailment January 15 - 22, 1992. Demand could have been reduced by approximately 1,000 MCF/day if boilers had been switched to oil during that time. A combination of switching boilers to fuel oil and a propane-air peak shaving system will produce greater savings.

3.4 ECIP Documentation And DD Form 1391

Since this project has an estimated cost exceeding $300,000, it may qualify for the Energy Conservation Investment Program (ECIP). The project Life Cycle Cost Analysis for the 1,500 MCF per day plant indicates the following:

Annual Savings, MCF Demand	-	1,500
Annual Cost Savings	-	$200,794
Total Investment	-	$970,050
Simple Payback	-	4.83 Years
Total Net Discounted Savings	-	$4,136,356
Savings To Investment Ratio (SIR)	-	4.26
Adjusted Internal Rate Of Return (AIRR)	-	12.00%

Based on this analysis, the project meets the other requirements to be recommended as an ECIP project since the simple payback is less than eight years and the savings to investment ratio is greater than 1.0.

On this basis, programming documentation consisting of DD Form 1391 for the 1,500 MCF per day plant and life cycle cost analysis summary sheets for all four plant sizes investigated are included in this section.

LIFE CYCLE COST ANALYSIS SUMMARY
ENERGY CONSERVATION INVESTMENT PROGRAM (ECIP)

LOCATION: Ft. Rucker REGION NO. 3 PROJECT NO. 2392
FISCAL YEAR 1993
PROJECT TITLE: Limited Energy Studies
DISCRETE PORTION NAME: 1000 MCF - Propane-Air Peak Shaving System
ANALYSIS DATE: 10/12/92 ECONOMIC LIFE 20 PREPARER Jackins

1. INVESTMENT COSTS:

A.	CONSTRUCTION COST	$ 715,000		
B.	SIOH	$ 39,325		
C.	DESIGN COST	$ 42,900		
D.	TOTAL COST (1A+1B+1C)	$ 797,225		
E.	SALVAGE VALUE OF EXISTING EQUIPMENT		$ 0	
F.	PUBLIC UTILITY COMPANY REBATE		$ 0	
G.	TOTAL INVESTMENT (1D-1E-1F)			$ 797,225

2. ENERGY SAVINGS (+)/COST(-):
DATE OF NISTIR 85-3273-X USED FOR DISCOUNT FACTORS Oct 1992

ENERGY SOURCE	COST $/MBTU(1)	SAVING MBTU/YR(2)	ANNUAL $ SAVINGS(3)	DISCOUNT FACTOR(4)	DISCOUNTED SAVINGS(5)
A. ELEC	$		$		$
B. DIST	$		$		$
C. RESID	$		$		$
D. NG	$ 2.89	45,956	$ 132,813	20.60	$ 2,735,948
E. PPG	$		$		$
F. COAL	$		$		$
G. SOLAR	$		$		$
H. GEOTH	$		$		$
I. BIOMA	$		$		$
J. REFUS	$		$		$
K. WIND	$		$		$
L. OTHER	$		$		$
M. DEMAND SAVINGS			$		$
N. TOTAL		45,956	$ 132,813		$ 2,735,948

3. NON ENERGY SAVINGS (+) OR COST (-):

A. ANNUAL RECURRING (+/-) $
(1) DISCOUNT FACTOR (TABLE A)
(2) DISCOUNTED SAVINGS/COST (3A X 3A1) $

B. NON RECURRING SAVINGS (+) OR COST (-)

ITEM	SAVINGS(+) COST(-)(1)	YEAR OF OCCUR. (2)	DISCOUNT FACTOR(3)	DISCOUNTED SAVINGS(+)COST(-)(4)
a.	$			$
b.	$			$
c.	$			$
d. TOTAL	$			$

C. TOTAL NON ENERGY DISCOUNTED SAVINGS (3A2+3Bd4) $

4. SIMPLE PAYBACK 1G/(2N3+3A+(3Bd1/ECONOMIC LIFE)): 6.00 YEARS
5. TOTAL NET DISCOUNTED SAVINGS (2N5+3C): $ 2,735,948
6. SAVINGS TO INVESTMENT RATIO (SIR) 5/1G: 3.43
7. ADJUSTED INTERNAL RATE OF RETURN (AIRR): 10.00%

LIFE CYCLE COST ANALYSIS SUMMARY
ENERGY CONSERVATION INVESTMENT PROGRAM (ECIP)

LOCATION: Ft. Rucker REGION NO. 3 PROJECT NO. 2392
FISCAL YEAR 1993
PROJECT TITLE: Limited Energy Studies
DISCRETE PORTION NAME: 1500 MCF - Propane-Air Peak Shaving System
ANALYSIS DATE: 10/12/92 ECONOMIC LIFE 20 PREPARER Jackins

1. INVESTMENT COSTS:

A.	CONSTRUCTION COST	$ 870,000		
B.	SIOH	$ 47,850		
C.	DESIGN COST	$ 52,200		
D.	TOTAL COST (1A+1B+1C)	$ 970,050		
E.	SALVAGE VALUE OF EXISTING EQUIPMENT		$ 0	
F.	PUBLIC UTILITY COMPANY REBATE		$ 0	
G.	TOTAL INVESTMENT (1D-1E-1F)			$ 970,050

2. ENERGY SAVINGS (+)/COST(-):
DATE OF NISTIR 85-3273-X USED FOR DISCOUNT FACTORS Oct 1992

ENERGY SOURCE	COST $/MBTU(1)	SAVING MBTU/YR(2)	ANNUAL $ SAVINGS(3)	DISCOUNT FACTOR(4)	DISCOUNTED SAVINGS(5)
A. ELEC	$		$		$
B. DIST	$		$		$
C. RESID	$		$		$
D. NG	$ 2.89	69,479	$ 200,794	20.60	$ 4,136,356
E. PPG	$		$		$
F. COAL	$		$		$
G. SOLAR	$		$		$
H. GEOTH	$		$		$
I. BIOMA	$		$		$
J. REFUS	$		$		$
K. WIND	$		$		$
L. OTHER	$		$		$
M. DEMAND SAVINGS			$		$
N. TOTAL		69,479	$ 200,794		$ 4,136,356

3. NON ENERGY SAVINGS (+) OR COST (-):

A. ANNUAL RECURRING (+/-) $
(1) DISCOUNT FACTOR (TABLE A)
(2) DISCOUNTED SAVINGS/COST (3A X 3A1) $

B. NON RECURRING SAVINGS (+) OR COST (-)

ITEM	SAVINGS(+) COST(-)(1)	YEAR OF OCCUR. (2)	DISCOUNT FACTOR(3)	DISCOUNTED SAVINGS(+)COST(-)(4)
a.	$			$
b.	$			$
c.	$			$
d. TOTAL	$			$

C. TOTAL NON ENERGY DISCOUNTED SAVINGS (3A2+3Bd4) $

4. SIMPLE PAYBACK 1G/(2N3+3A+(3Bd1/ECONOMIC LIFE)): 4.83 YEARS
5. TOTAL NET DISCOUNTED SAVINGS (2N5+3C): $4,136,356
6. SAVINGS TO INVESTMENT RATIO (SIR) 5/1G: 4.26
7. ADJUSTED INTERNAL RATE OF RETURN (AIRR): 12.00 %

LIFE CYCLE COST ANALYSIS SUMMARY
ENERGY CONSERVATION INVESTMENT PROGRAM (ECIP)

LOCATION: Ft. Rucker REGION NO. 3 PROJECT NO. 2392
FISCAL YEAR 1993
PROJECT TITLE: Limited Energy Studies
DISCRETE PORTION NAME: 2000 MCF - Propane-Air Peak Shaving System
ANALYSIS DATE: 10/12/92 ECONOMIC LIFE 20 PREPARER Jackins

1. INVESTMENT COSTS:

A.	CONSTRUCTION COST	$ 1,050,000		
B.	SIOH	$ 57,750		
C.	DESIGN COST	$ 63,000		
D.	TOTAL COST (1A+1B+1C)	$ 1,170,750		
E.	SALVAGE VALUE OF EXISTING EQUIPMENT		$ 0	
F.	PUBLIC UTILITY COMPANY REBATE		$ 0	
G.	TOTAL INVESTMENT (1D-1E-1F)			$ 1,170,750

2. ENERGY SAVINGS (+)/COST(-):
DATE OF NISTIR 85-3273-X USED FOR DISCOUNT FACTORS Oct 1992

ENERGY SOURCE	COST $/MBTU(1)	SAVING MBTU/YR(2)	ANNUAL $ SAVINGS(3)	DISCOUNT FACTOR(4)	DISCOUNTED SAVINGS(5)
A. ELEC	$		$		$
B. DIST	$		$		$
C. RESID	$		$		$
D. NG	$ 2.89	92,636	$ 267,718	20.60	$ 5,514,991
E. PPG	$		$		$
F. COAL	$		$		$
G. SOLAR	$		$		$
H. GEOTH	$		$		$
I. BIOMA	$		$		$
J. REFUS	$		$		$
K. WIND	$		$		$
L. OTHER	$		$		$
M. DEMAND SAVINGS			$		$
N. TOTAL		92,636	$ 267,718		$ 5,514,991

3. NON ENERGY SAVINGS (+) OR COST (-):

A. ANNUAL RECURRING (+/-) $
(1) DISCOUNT FACTOR (TABLE A)
(2) DISCOUNTED SAVINGS/COST (3A X 3A1) $

B. NON RECURRING SAVINGS (+) OR COST (-)

ITEM	SAVINGS(+) COST(-)(1)	YEAR OF OCCUR. (2)	DISCOUNT FACTOR(3)	DISCOUNTED SAVINGS(+)COST(-)(4)
a.	$			$
b.	$			$
c.	$			$
d. TOTAL	$			$

C. TOTAL NON ENERGY DISCOUNTED SAVINGS (3A2+3Bd4) $

4. SIMPLE PAYBACK 1G/(2N3+3A+(3Bd1/ECONOMIC LIFE)): 4.37 YEARS
5. TOTAL NET DISCOUNTED SAVINGS (2N5+3C): $ 5,514,991
6. SAVINGS TO INVESTMENT RATIO (SIR) 5/1G: 4.71
7. ADJUSTED INTERNAL RATE OF RETURN (AIRR): 12.00%

LIFE CYCLE COST ANALYSIS SUMMARY
ENERGY CONSERVATION INVESTMENT PROGRAM (ECIP)

LOCATION: Ft. Rucker REGION NO. 3 PROJECT NO. 2392
FISCAL YEAR 1993
PROJECT TITLE: Limited Energy Studies
DISCRETE PORTION NAME: 2500 MCF - Propane-Air Peak Shaving System
ANALYSIS DATE: 10/12/92 ECONOMIC LIFE 20 PREPARER Jackins

1. INVESTMENT COSTS:

A.	CONSTRUCTION COST	$ 1,240,000		
B.	SIOH	$ 68,200		
C.	DESIGN COST	$ 74,400		
D.	TOTAL COST (1A+1B+1C)	$ 1,382,600		
E.	SALVAGE VALUE OF EXISTING EQUIPMENT		$ 0	
F.	PUBLIC UTILITY COMPANY REBATE		$ 0	
G.	TOTAL INVESTMENT (1D-1E-1F)			$ 1,382,600

2. ENERGY SAVINGS (+)/COST(-):
DATE OF NISTIR 85-3273-X USED FOR DISCOUNT FACTORS Oct 1992

ENERGY SOURCE	COST $/MBTU(1)	SAVING MBTU/YR(2)	ANNUAL $ SAVINGS(3)	DISCOUNT FACTOR(4)	DISCOUNTED SAVINGS(5)
A. ELEC	$		$		$
B. DIST	$		$		$
C. RESID	$		$		$
D. NG	$ 2.89	111,163	$ 321,261	20.60	$ 6,617,977
E. PPG	$		$		$
F. COAL	$		$		$
G. SOLAR	$		$		$
H. GEOTH	$		$		$
I. BIOMA	$		$		$
J. REFUS	$		$		$
K. WIND	$		$		$
L. OTHER	$		$		$
M. DEMAND SAVINGS			$		$
N. TOTAL		111,163	$ 321,261		$ 6,617,977

3. NON ENERGY SAVINGS (+) OR COST (-):

A. ANNUAL RECURRING (+/-) $
(1) DISCOUNT FACTOR (TABLE A)
(2) DISCOUNTED SAVINGS/COST (3A X 3A1) $

B. NON RECURRING SAVINGS (+) OR COST (-)

ITEM	SAVINGS(+) COST(-)(1)	YEAR OF OCCUR. (2)	DISCOUNT FACTOR(3)	DISCOUNTED SAVINGS(+)COST(-)(4)
a.	$			$
b.	$			$
c.	$			$
d. TOTAL	$			$

C. TOTAL NON ENERGY DISCOUNTED SAVINGS (3A2+3Bd4) $

4. SIMPLE PAYBACK 1G/(2N3+3A+(3Bd1/ECONOMIC LIFE)): 4.30 YEARS
5. TOTAL NET DISCOUNTED SAVINGS (2N5+3C): $6,617,977
6. SAVINGS TO INVESTMENT RATIO (SIR) 5/1G: 4.79
7. ADJUSTED INTERNAL RATE OF RETURN (AIRR): 12.00 %

1. COMPONENT	FY 19 93 MILITARY CONSTRUCTION PROJECT DATA	2. DATE
ARMY		25 March 93

3. INSTALLATION AND LOCATION	4. PROJECT TITLE
Fort Rucker Alabama	ECIP

5. PROGRAM ELEMENT	6. CATEGORY CODE	7. PROJECT NUMBER	8. PROJECT COST ($000)
	80000		970

9. COST ESTIMATES

ITEM	U/M	QUANTITY	UNIT COST	COST ($000)
30,000 Gallon Propane Tanks And Trim	EA	5	75,000	375
Truck Transport Unload Station	LS	--	--	18
Duplex Liquid Pumping System	LS	--	--	17
Vaporizer/Mixer Unit	LS	--	--	180
Dual Air Compressor System	LS	--	--	120
Peak Shaving Controls	LS	--	--	95
Building	LS	--	--	65
Supervision, Inspection & Overhead (5.5%)				48
Design (6.0%)				52
TOTAL				970

10. DESCRIPTION OF PROPOSED CONSTRUCTION

The primary facility of the propane-air peak shaving system will include storage tanks, a high capacity truck unload station, a duplex liquid pumping system with controls, vaporizer, mixer with control package, air compressors, flow control package and building. The work is new construction at Fort Rucker. The purpose of this facility is to reduce overall natural gas cost by reducing the monthly demand charge for natural gas. Demolition of existing buildings is not required for site clearance. Accessibility for the handicapped is not required for functional reasons.

11. Project:

Install a propane-air peak shaving facility. This project will save $200,794 per year and 69,479 MBTU per year of natural gas.

DD FORM 1391 1 DEC 76 PREVIOUS EDITIONS MAY BE USED INTERNALLY UNTIL EXHAUSTED. PAGE NO.

FOR OFFICIAL USE ONLY

(WHEN DATA IS ENTERED)

1. COMPONENT	FY 1993 MILITARY CONSTRUCTION PROJECT DATA	2. DATE
ARMY		25 March 93

3. INSTALLATION AND LOCATION	
Fort Rucker Alabama	
4. PROJECT TITLE	5. PROJECT NUMBER
ECIP	

REQUIREMENT:

This project is required to provide a reduction of overall natural gas cost by reducing the monthly demand charge for natural gas by utilizing a propane-air peak shaving system during a period of curtailment. The project has a Savings To Investment Ratio (SIR) of 4.26. The ECIP Life Cycle Cost Analysis summary sheet is attached.

CURRENT SITUATION:

Fort Rucker is billed for natural gas demand charges each month by establishing the highest daily usage during a period of curtailment. This one day demand sets the basis for demand charges for the following eleven months. An LP Gas Storage plant would reduce this one day demand during curtailment resulting in a lower delivered natural gas cost for the rest of the year.

IMPACT:

Fort Rucker will continue to set the same demand usage during curtailment and will lose a potential annual savings of $200,794 in natural gas demand costs.

DD FORM 1391c, 1 DEC 76 — PREVIOUS EDITIONS MAY BE USED INTERNALLY UNTIL EXHAUSTED — PAGE NO.

FOR OFFICIAL USE ONLY
(WHEN DATA IS ENTERED)

SECTION 3.0 APPENDIX

LP GAS STORAGE

FORT RUCKER

APPENDIX 3A

NATURAL GAS BILLING HISTORY

GD-151

THE SOUTHEAST ALABAMA GAS DISTRICT
POST OFFICE BOX 1330
ANDALUSIA, ALABAMA 36420

25-1002

DATE January 8, 1992

SOLD TO
DEH
Building 1404
Utilities Division
Fort Rucker, Alabama 36362

PLEASE MAKE REMITTANCE TO
Andalusia Office

SERVICE ADDRESS Fort Rucker

DABTO 1-74-0153

DATE EXPLANATION OF CHARGE	AMOUNT
December 1991	
Meter Station #12405	
See Analysis Sheet for meter readings and consumption = 33,701 Mcf.	
Meter Station #12301 and #12302	
For daily consumption and meter readings see attached monthly meter analysis sheets: 32,251 Mcf.	
Commodity Charge:	
65,952 Mcf @ $3.035760 per Mcf	$200,214.
Add BTU adjustment @ 2.22%	4,444.
	204,659.
Demand Charge:	
3,234 Mcf @ $21.468300 per Mcf	69,428.
Balance Due	$274,087

Average BTU content for the month was 1022.19.

Billing Demand Mcf established February 15, 1991.

Sworn to and subscribed be
this 8th day of January 1

Notary Public

My Commission Expires

I certify that this bill is correct and just; that payment therefor has not been received; that all statutory requirements as to American production and labor standards, and all conditions of purchase applicable to the transactions have been complied with and that State or local sales taxes are not included in the amounts billed

By Clerk

ORT CKER DECEMBER 1991

DATE OUT ON	TEMP	SP.GR.	BTU	EXT. FACTOR	12405 MCF	12301 INT.DIF	12301 COEFF.	MCF	12302 INT.DIF	12302 COEFF.	MCF	TOTAL DAY
01-Dec	0	0.572	1022	1.4058	1126	0	375.14	0	0	620.39	0	1126
02-Dec	55	0.571	1021	1.3298	1017	244	375.14	122	0	620.39	0	1139
03-Dec	51	0.569	1019	1.3374	1260	532	375.14	267	202	620.39	168	1695
04-Dec	51	0.571	1021	1.3350	1136	3047	375.14	1526	818	620.39	677	3339
05-Dec	49	0.574	1024	1.3340	1268	2806	375.14	1404	659	620.39	545	3217
06-Dec	48	0.573	1022	1.3366	1123	2400	375.14	1203	0	620.39	0	2326
07-Dec	48	0.572	1021	1.3377	865	1878	375.14	942	0	620.39	0	1807
08-Dec	48	0.573	1023	1.3366	1102	1309	375.14	656	0	620.39	0	1758
09-Dec	51	0.573	1023	1.3327	892	857	375.14	428	0	620.39	0	1320
10-Dec	49	0.573	1023	1.3352	974	1881	375.14	942	0	620.39	0	1916
11-Dec	48	0.573	1023	1.3366	906	1625	375.14	815	0	620.39	0	1721
12-Dec	50	0.573	1023	1.3340	1107	882	375.14	441	0	620.39	0	1548
13-Dec	51	0.573	1023	1.3327	980	270	375.14	135	0	620.39	0	1115
14-Dec	49	0.572	1022	1.3363	1075	1166	375.14	585	0	620.39	0	1660
15-Dec	49	0.571	1021	1.3376	1083	1954	375.14	980	87	620.39	72	2135
16-Dec	49	0.571	1021	1.3376	1135	2485	375.14	1247	314	620.39	261	2643
17-Dec	47	0.575	1023	1.3355	1126	2400	375.14	1202	132	620.39	109	2437
18-Dec	47	0.575	1024	1.3355	1160	2497	375.14	1251	249	620.39	206	2617
19-Dec	47	0.575	1024	1.3355	1335	2921	375.14	1463	709	620.39	587	3385
20-Dec	46	0.573	1023	1.3392	1164	2505	375.14	1258	301	620.39	250	2672
21-Dec	46	0.572	1022	1.3403	925	1842	375.14	926	0	620.39	0	1851
22-Dec	46	0.572	1022	1.3403	892	1843	375.14	927	0	620.39	0	1819
23-Dec	48	0.572	1022	1.3377	854	1593	375.14	799	0	620.39	0	1653
24-Dec	46	0.571	1022	1.3415	1174	2530	375.14	1273	0	620.39	0	2447
25-Dec	46	0.571	1022	1.3415	1078	2341	375.14	1178	0	620.39	0	2256
26-Dec	46	0.572	1022	1.3403	1007	2151	375.14	1082	0	620.39	0	2089
27-Dec	47	0.572	1022	1.3390	1094	2305	375.14	1158	0	620.39	0	2252
28-Dec	46	0.573	1023	1.3392	951	2001	375.14	1005	0	620.39	0	1956
29-Dec	46	0.571	1022	1.3415	1239	2622	375.14	1320	0	620.39	0	2559
30-Dec	46	0.571	1021	1.3415	1455	3065	375.14	1542	0	620.39	0	2997
31-Dec	45	0.572	1022	1.3416	1198	2581	375.14	1299	0	620.39	0	2497
*** TOTALS **		17.741	31688	********	33701	*******	*********	29376	*******	*********	2875	

AVERAGE BTU @ 14.73 = 1022.19

CORRECTED
RUN 12405 1-1-92 163859
12-1-91 130158
===============
TOTAL 33701

TOTAL DELIVERY THIS CUSTOMER 65952

PREPARED BY:

NOTE EST. MADE ON THE 25TH 12301

[redacted]

GD-151

THE SOUTHEAST ALABAMA GAS DISTRICT
POST OFFICE BOX 1338
ANDALUSIA, ALABAMA 36420

25-1002

DATE February 10, 1992

PLEASE MAKE REMITTANCE TO

SOLD TO
DEH
Building 1404
Utilities Division
Fort Rucker, Alabama 36362

SERVICE ADDRESS Fort Rucker DABTO 1-74-0153

DATE	EXPLANATION OF CHARGE	AMOUNT
	January 1992	
	Meter Station #12405	
	See Analysis Sheet for meter readings and consumption = 36,631	
	Meter Station #12301 and #12302	
	For daily consumption and meter readings see attached monthly meter analysis sheets: 42,086 Mcf.	
	Commodity Charge:	
	78,717 Mcf @ $2.998000 per Mcf............	$235,993.57
	Add BTU adjustment @ 2.21%............	5,215.46
		241,209.03
	Demand Charge:	
	3,436 Mcf @ $21.512300 per Mcf............	73,916.26
	Balance due...........	$315,125.29
	Average BTU content for the month was 1022.10.	
	Billing Demand Mcf established January 16, 1992	

I certify that this bill is correct and just; that payment therefor has not been received; that all statutory requirements as to American production and labor standards, and all conditions of purchase applicable to the transactions have been complied with and that State or local sales taxes are not included in the amounts billed.

By [signature] Clerk

Sworn to and subscribed before me
this 10th day of Feb 1992
[signature] Notary Public

THE SOUTHEAST ALABAMA GAS DISTRICT
GAS CONTROL DEPT.

FORT RUCKER January 1992

DATE PUT ON	TEMP	SP.GR.	BTU	EXT. FACTOR	12405 MCF	12301 INT.DIF	12301 COEFF.	MCF	12302 INT.DIF	12302 COEFF.	MCF	TOTAL DAY
01-Jan	45	0.573	1022	1.3405	1154	2375	375.14	1194	0	620.39	0	2348
02-Jan	45	0.576	1023	1.3370	1175	2529	375.14	1268	0	620.39	0	2443
03-Jan	45	0.575	1023	1.3382	1219	2641	375.14	1326	0	620.39	0	2545
04-Jan	44	0.572	1022	1.3430	1133	2421	375.14	1220	0	620.39	0	2353
05-Jan	44	0.572	1022	1.3430	1172	2469	375.14	1244	0	620.39	0	2416
06-Jan	44	0.571	1021	1.3442	1127	2375	375.14	1198	0	620.39	0	2383
07-Jan	44	0.572	1022	1.3430	1037	2234	375.14	1126	70	620.39	58	2251
08-Jan	44	0.574	1022	1.3406	1036	2139	375.14	1076	106	620.39	88	2112
09-Jan	46	0.573	1023	1.3392	904	1868	375.14	938	0	620.39	0	1842
10-Jan	45	0.573	1023	1.3405	1365	2898	375.14	1457	0	620.39	0	2987
11-Jan	44	0.572	1022	1.3430	1186	2514	375.14	1267	198	620.39	165	2640
12-Jan	45	0.572	1021	1.3416	923	1918	375.14	965	225	620.39	187	1888
13-Jan	46	0.571	1021	1.3415	950	1963	375.14	988	0	620.39	0	1938
14-Jan	45	0.575	1019	1.3382	1537	3243	375.14	1628	0	620.39	0	3411
* 15-Jan	43	0.572	1022	1.3444	1249	2211	375.14	1115	296	620.39	246	2775 *
* 16-Jan	43	0.573	1023	1.3433	1347	2975	375.14	1499	493	620.39	411	3436 *
* 17-Jan	41	0.572	1022	1.3471	1154	2507	375.14	1267	708	620.39	590	2642 *
* 18-Jan	42	0.573	1023	1.3446	1440	3036	375.14	1531	265	620.39	221	2971 *
* 19-Jan	40	0.573	1023	1.3473	1426	2594	375.14	1311	0	620.39	0	2855 *
* 20-Jan	39	0.572	1022	1.3497	1179	2596	375.14	1314	141	620.39	118	2874 *
* 21-Jan	39	0.572	1022	1.3497	1195	2597	375.14	1315	455	620.39	381	2676 *
* 22-Jan	41	0.574	1023	1.3447	1127	2422	375.14	1222	198	620.39	166	2349 *
23-Jan	41	0.573	1022	1.3459	1116	2379	375.14	1201	0	620.39	0	2512
24-Jan	41	0.572	1022	1.3471	1279	2851	375.14	1441	234	620.39	195	3014
25-Jan	42	0.572	1022	1.3457	1187	2529	375.14	1277	352	620.39	294	2464
26-Jan	41	0.572	1022	1.3471	1011	2143	375.14	1083	0	620.39	0	2094
27-Jan	42	0.573	1023	1.3446	1174	2501	375.14	1262	0	620.39	0	2436
28-Jan	42	0.573	1022	1.3446	1295	2752	375.14	1388	0	620.39	0	2683
29-Jan	42	0.572	1022	1.3457	1245	2642	375.14	1334	0	620.39	0	2579
30-Jan	42	0.572	1022	1.3457	1180	2510	375.14	1267	0	620.39	0	2506
31-Jan	43	0.572	1022	1.3444	1109	2349	375.14	1185	71	620.39	59	2294
*** TOTALS **		17.753	31685	********	36631	*******	*********	38907	*******	*********	3179	

AVERAGE BTU @ 14.73 =1022.097

PREPARED BY:
Randall Grimes
2-7-92

Off Reading ---	200490
On Reading ----	163859
Total 12405 =	36631

TOTAL DELIVERY THIS CUSTOMER 78717
****

NOTE: UNDER CONTRACT DEMAND FROM;
JAN. 15 08:00 TO JAN. 23 08:30

NOTE: Billing Demand mcf of 3,436
was established 16 January 1992.

GD-151

THE SOUTHEAST ALABAMA GAS DISTRICT

POST OFFICE BOX 1338
ANDALUSIA, ALABAMA 36420

25-1002

DATE March 6, 1992

SOLD TO
DEH
Building 1404
Utilities Division
Fort Rucker, Alabama 36362

PLEASE MAKE REMITTANCE TO
Andalusia Office

SERVICE ADDRESS Fort Rucker

DABTO 1-74-0153

DATE	EXPLANATION OF CHARGE	AMOUNT
	February 1992	
	Meter Station # 12405	
	See Analysis Sheet for meter readings and consumption = 29,950 Mcf.	
	Meter Station #12301 and #12302	
	For daily consumption and meter readings see attached monthly meter analysis sheets: 30,952 Mcf.	
	Commodity Charge:	
	60,902 Mcf @ $2.848320 per Mcf	$173,468.38
	Add BTU adjustment @ 2.11%	3,660.18
		177,128.56
	Demand Charge:	
	3,436 Mcf @ $21.512300 per Mcf	73,916.26
	Balance due	$251,044.82

Average Btu content for the month was 1021.14.

Billing Demand Mcf established January 16, 1992.

I certify that this bill is correct and just; that payment therefor has not been received; that all statutory requirements as to American production and labor standards, and all conditions of purchase applicable to the transaction have been complied with and that State or local sales taxes are not included in the amounts billed.

By ______________ **Clerk**

Sworn to and subscribed before me this 9th day of March 1992

____
Notary Public
My Commission Expires Feb. 14, 1996

THE SOUTHEAST ALABAMA GAS DISTRICT
GAS CONTROL DEPT.

FORT RUCKER FEBRUARY 1992

DATE PUT ON	TEMP	SP.GR.	BTU	EXT. FACTOR	12405 MCF	12301 INT.DIF	12301 COEFF.	MCF	12302 INT.DIF	12302 COEFF.	MCF	TOTAL DAY
01-Feb	43	0.573	1023	1.3433	1133	2423	375.14	1221	0	620.39	0	2354
02-Feb	42	0.573	1023	1.3446	1246	2679	375.14	1351	0	620.39	0	2597
03-Feb	43	0.572	1022	1.3444	1109	2399	375.14	1210	175	620.39	146	2465
04-Feb	43	0.572	1023	1.3444	935	2044	375.14	1031	154	620.39	128	2094
05-Feb	43	0.572	1022	1.3444	1164	2505	375.14	1263	0	620.39	0	2427
06-Feb	43	0.571	1021	1.3456	1438	3043	375.14	1536	0	620.39	0	2974
07-Feb	43	0.572	1022	1.3444	1348	2854	375.14	1439	0	620.39	0	2787
08-Feb	42	0.571	1021	1.3470	1397	2986	375.14	1509	74	620.39	62	2968
09-Feb	41	0.571	1021	1.3483	1229	2733	375.14	1382	493	620.39	412	3023
10-Feb	41	0.571	1021	1.3483	1133	2528	375.14	1279	440	620.39	368	2780
11-Feb	41	0.571	1020	1.3483	1110	2418	375.14	1223	283	620.39	237	2570
12-Feb	42	0.571	1020	1.3470	970	2137	375.14	1080	0	620.39	0	2050
13-Feb	43	0.571	1021	1.3456	903	1957	375.14	989	0	620.39	0	1892
14-Feb	45	0.572	1021	1.3416	733	1601	375.14	806	0	620.39	0	1539
15-Feb	46	0.571	1021	1.3415	701	1553	375.14	782	0	620.39	0	1483
16-Feb	46	0.572	1022	1.3403	670	1469	375.14	739	0	620.39	0	1409
17-Feb	47	0.571	1021	1.3402	770	1695	375.14	852	0	620.39	0	1622
18-Feb	47	0.572	1021	1.3390	802	1712	375.14	860	0	620.39	0	1662
19-Feb	48	0.571	1020	1.3389	918	2006	375.14	1008	0	620.39	0	1926
20-Feb	46	0.571	1020	1.3415	1075	2275	375.14	1145	0	620.39	0	2220
21-Feb	46	0.571	1021	1.3415	999	1373	375.14	691	0	620.39	0	1690
22-Feb	47	0.572	1020	1.3390	780	1617	375.14	812	0	620.39	0	1592
23-Feb	49	0.571	1020	1.3376	1116	819	375.14	411	0	620.39	0	1527
24-Feb	49	0.571	1020	1.3376	996	698	375.14	350	0	620.39	0	1346
25-Feb	51	0.572	1021	1.3338	1014	393	375.14	197	0	620.39	0	1211
26-Feb	47	0.572	1021	1.3390	1276	2724	375.14	1368	155	620.39	129	2773
27-Feb	47	0.573	1022	1.3379	1111	2413	375.14	1211	245	620.39	203	2525
28-Feb	47	0.573	1021	1.3379	856	1846	375.14	927	0	620.39	0	1783
29-Feb	46	0.572	1021	1.3403	1018	1184	375.14	595	0	620.39	0	1613
TOTALS		16.578	29613		29950			29267			1685	60902

AVERAGE BTU @ 14.73 =1021.138 METER 12405 TOTAL DELIVERY THIS CUSTOMER 60902

3-1-92 230440

2-1-92 200490

TOTAL 29950

PREPARED BY:

3-5-9

GD-151

THE SOUTHEAST ALABAMA GAS DISTRICT
POST OFFICE BOX 1338
ANDALUSIA, ALABAMA 36420

25-1002

DATE April 7, 1992

PLEASE MAKE REMITTANCE TO

Andalusia Office

OLD TO

DEH
Building 1404
Utilities Division
Fort Rucker, Alabama 36362

DABTO 1-74-0153

SERVICE ADDRESS Fort Rucker

DATE	EXPLANATION OF CHARGE	AMOUNT
	March 1992	
	Meter Station #12405	
	See Analysis Sheet for meter readings and consumption = 32,322 Mcf.	
	Meter Station #12301 and #12302	
	For daily consumption and meter readings see attached monthly meter analysis sheets: 19,701 Mcf.	
	Commodity Charge:	
	52,023 Mcf @ $2.782370 per Mcf	$144,747.23
	Add BTU adjustment @ 2.07%	2,996.27
		147,743.50
	Demand Charge:	
	3,436 Mcf @ $9.069300 per Mcf	31,162.11
	Balance Due	$178,905.61

Average BTU content for the month was 1020.71.

Billing Demand Mcf established January 16, 1992.

I certify that this bill is correct and just; that payment therefor has not been received; that all statutory requirements as to American production and labor standards, and all conditions of purchase applicable to the transactions have been complied with and that State or local sales taxes are not included in the amounts billed.

By [signature] Clerk

Sworn to and subscribed before me this 7th day of April 1992

[signature]
Notary Public

My Commission Expires Feb. 14, 1996

THE SOUTHEAST ALABAMA GAS DISTRICT
GAS CONTROL DEPT.

FORT RUCKER MARCH 1992

DATE PUT ON	TEMP	SP.GR.	BTU	EXT. FACTOR	12405 MCF	12301 INT.DIF	12301 COEFF.	MCF	12302 INT.DIF	12302 COEFF.	MCF	TOTAL DAY
01-Mar	49	0.571	1020	1.3376	1169	691	375.14	347	0	620.39	0	1516
02-Mar	50	0.572	1021	1.3352	1045	683	375.14	342	0	620.39	0	1387
03-Mar	49	0.572	1021	1.3363	1078	456	375.14	229	0	620.39	0	1307
04-Mar	51	0.572	1021	1.3338	1045	368	375.14	184	0	620.39	0	1229
05-Mar	50	0.572	1021	1.3352	863	927	375.14	464	0	620.39	0	1327
06-Mar	52	0.572	1021	1.3325	1110	228	375.14	114	0	620.39	0	1224
07-Mar	0	0.572	1021	1.4058	1027	0	375.14	0	0	620.39	0	1027
08-Mar	50	0.572	1021	1.3352	1096	113	375.14	57	0	620.39	0	1153
09-Mar	54	0.573	1022	1.3288	1072	160	375.14	80	0	620.39	0	1152
10-Mar	49	0.572	1020	1.3363	1315	1537	375.14	770	91	620.39	75	2160
11-Mar	50	0.571	1020	1.3364	1281	2764	375.14	1386	319	620.39	264	2931
12-Mar	49	0.572	1021	1.3363	1148	2429	375.14	1218	0	620.39	0	2366
13-Mar	49	0.571	1019	1.3376	1092	2308	375.14	1158	0	620.39	0	2250
14-Mar	49	0.571	1020	1.3376	1025	1316	375.14	660	0	620.39	0	1685
15-Mar	49	0.572	1021	1.3363	1007	1436	375.14	720	0	620.39	0	1727
16-Mar	49	0.572	1021	1.3363	1095	1856	375.14	930	0	620.39	0	2025
17-Mar	51	0.575	1021	1.3304	1000	539	375.14	269	0	620.39	0	1269
18-Mar	49	0.576	1023	1.3317	1042	774	375.14	387	0	620.39	0	1429
19-Mar	50	0.576	1023	1.3305	1125	474	375.14	237	0	620.39	0	1362
20-Mar	49	0.572	1021	1.3363	942	1976	375.14	991	0	620.39	0	1933
21-Mar	48	0.572	1021	1.3377	901	1899	375.14	953	0	620.39	0	1854
22-Mar	48	0.571	1020	1.3389	864	1842	375.14	925	0	620.39	0	1789
23-Mar	48	0.572	1021	1.3377	1192	2523	375.14	1266	63	620.39	52	2510
24-Mar	48	0.572	1021	1.3377	947	2019	375.14	1013	0	620.39	0	1960
25-Mar	48	0.571	1020	1.3389	683	1893	375.14	951	0	620.39	0	1634
26-Mar	49	0.572	1020	1.3363	1166	1403	375.14	703	0	620.39	0	1869
27-Mar	50	0.571	1020	1.3364	964	1306	375.14	655	0	620.39	0	1619
28-Mar	51	0.571	1020	1.3350	1214	540	375.14	270	0	620.39	0	1484
29-Mar	49	0.571	1020	1.3376	748	1597	375.14	801	0	620.39	0	1549
30-Mar	51	0.571	1020	1.3350	1061	877	375.14	439	0	620.39	0	1500
31-Mar	51	0.571	1020	1.3350	1005	1579	375.14	791	0	620.39	0	1796
*** TOTALS **		17.733	31642	********	32322	*******	*********	19310	*******	*********	391	52023

AVERAGE BTU @	=1020.710	Off Reading — 262762	TOTAL DELIVERY THIS CUSTOMER 52023
		On Reading — 230440	
PREPARED BY:			
Randall Grimes		Total 12405 = 32322	

4-6-92

GO-151

THE SOUTHEAST ALABAMA GAS DISTRIC
POST OFFICE BOX 1336
ANDALUSIA, ALABAMA 36420

25-1002

DATE May 4, 1992

SOLD TO
DEH
Building 1404
Utilities Division
Fort Rucker, Alabama 36362

PLEASE MAKE REMITTANCE TO
Andalusia Office

SERVICE ADDRESS Fort Rucker DABTO 1-74-0153

DATE	EXPLANATION OF CHARGE	AMOUNT
	April 1992	
	Meter Station #12405	
	See analysis sheet for meter readings and consumption= 26,690 Mcf.	
	Meter Station #12301 and #12302	
	For daily consumption and meter readings see attached monthly meter analysis sheets: 6,671 Mcf.	
	Commodity Charge:	
	33,361 Mcf @ $2.556120 per Mcf....................................	$ 85,274.72
	Add Btu adjustment @ 2.037%....................................	1,737.05
		87,011.77
	Demand Charge:	
	3,436 Mcf @ $8.952300 per Mcf....................................	30,760.10
	Balance due................	$117,771.87

Average Btu content for the month was 1020.37.

Billing Demand Mcf established January 16, 1992.

I certify that this bill is correct and just; that payment therefor has not been received; that all statutory requirements as to American production and labor standards, and all conditions of purchase applicable to the transaction have been complied with and that State or local sales taxes are not included in the amounts billed.

By _______ Clerk

Sworn to and subscribed before me
this 5th day of May 1992

Notary Public

My Commission Expires Feb. 14, 1996

GO-181

THE SOUTHEAST ALABAMA GAS DISTRICT

POST OFFICE BOX 1336
ANDALUSIA, ALABAMA 36420

25-1002

DATE June 4, 1992

SOLD TO
DEH
Building 1404
Utilities Division
Fort Rucker, Alabama 36362

PLEASE MAKE REMITTANCE TO
Andalusia Office

SERVICE ADDRESS Fort Rucker DABTO-1-74-0153

DATE	EXPLANATION OF CHARGE	AMOUNT
	May 1992	
	Meter Station #12405	
	See analysis sheet for meter readings and consumption = 28,808 Mcf.	
	Meter Stations #12301 and #12302	
	For daily consumption and meter readings see attached monthly meter analysis sheets: 1,571 Mcf.	
	Commodity Charge:	
	30,379 Mcf @ $2.655040 per Mcf..........	$ 80,657.46
	Add Btu adjustment @ 2.177%..........	1,755.91
		82,413.37
	Demand Charge:	
	3,436 Mcf @ $8.952300 per Mcf..........	30,760.10
	Balance due....	$113,173.47

Average Btu content for the month was 1021.77.

Billing Demand Mcf established January 16, 1992.

I certify that this bill is correct and just; that payment therefor has not been received; that all statutory requirements as to American production and labor standards, and all conditions of purchase applicable to the transactions have been complied with and that State or local sales taxes are not included in the amounts billed.

By [signature] Clerk

Sworn to and subscribed before me this 4th day of June 1992

[signature]
Notary Public

My Commission Expires Feb. 14, 1995

THE SOUTHEAST ALABAMA GAS DISTRICT
GAS CONTROL DEPT.

FORT RUCKER MAY 1992

DATE PUT ON	TEMP	SP.GR.	BTU	EXT. FACTOR	12405 MCF	12301 INT.DIF	12301 COEFF.	MCF	12302 INT.DIF	12302 COEFF.	MCF	TOTAL DAY
01-May	65	0.572	1022	1.3159	964	71	375.14	35	0	620.39	0	999
02-May	0	0.572	1021	1.4058	934	0	375.14	0	0	620.39	0	934
03-May	0	0.572	1021	1.4058	1014	0	375.14	0	0	620.39	0	1014
04-May	66	0.572	1021	1.3147	1034	27	375.14	13	0	620.39	0	1047
05-May	58	0.572	1021	1.3247	1036	84	375.14	42	0	620.39	0	1078
06-May	59	0.571	1020	1.3247	1028	715	375.14	355	0	620.39	0	1383
07-May	57	0.570	1019	1.3283	760	1620	375.14	807	0	620.39	0	1567
08-May	62	0.570	1019	1.3220	936	390	375.14	193	0	620.39	0	1129
09-May	0	0.570	1019	1.4082	946	0	375.14	0	0	620.39	0	946
10-May	0	0.572	1020	1.4058	1026	0	375.14	0	0	620.39	0	1026
11-May	61	0.572	1020	1.3209	973	151	375.14	75	0	620.39	0	1048
12-May	62	0.571	1020	1.3209	985	103	375.14	51	0	620.39	0	1036
13-May	0	0.571	1020	1.4070	1078	0	375.14	0	0	620.39	0	1078
14-May	0	0.571	1019	1.4070	1073	0	375.14	0	0	620.39	0	1073
15-May	0	0.571	1019	1.4070	1030	0	375.14	0	0	620.39	0	1030
16-May	0	0.570	1019	1.4082	1035	0	375.14	0	0	620.39	0	1035
17-May	0	0.572	1022	1.4058	977	0	375.14	0	0	620.39	0	977
18-May	0	0.571	1020	1.4070	946	0	375.14	0	0	620.39	0	946
19-May	0	0.576	1028	1.4009	802	0	375.14	0	0	620.39	0	802
20-May	0	0.581	1036	1.3948	793	0	375.14	0	0	620.39	0	793
21-May	0	0.582	1037	1.3936	829	0	375.14	0	0	620.39	0	829
22-May	0	0.579	1035	1.3973	766	0	375.14	0	0	620.39	0	766
23-May	0	0.571	1019	1.4070	683	0	375.14	0	0	620.39	0	683
24-May	0	0.570	1018	1.4082	658	0	375.14	0	0	620.39	0	658
25-May	0	0.569	1018	1.4095	752	0	375.14	0	0	620.39	0	752
26-May	0	0.571	1021	1.4070	815	0	375.14	0	0	620.39	0	815
27-May	0	0.571	1020	1.4070	910	0	375.14	0	0	620.39	0	910
28-May	0	0.570	1019	1.4082	1035	0	375.14	0	0	620.39	0	1035
29-May	0	0.571	1020	1.4070	1020	0	375.14	0	0	620.39	0	1020
30-May	0	0.571	1021	1.4070	979	0	375.14	0	0	620.39	0	979
31-May	0	0.571	1021	1.4070	991	0	375.14	0	0	620.39	0	991
*** TOTALS **		17.735	31675	********	28808	*******	*********	1571	*******	*********	0	

AVERAGE BTU @ 14.73 =1021.774 | Off Reading --- 310953 | TOTAL DELIVERY THIS CUSTOMER 30379
On Reading ---- 282145

GD-151

THE SOUTHEAST ALABAMA GAS DISTRICT

POST OFFICE BOX 1338
ANDALUSIA, ALABAMA 36420

DATE July 7, 1992

SOLD TO
DEH
Building 1404
Utilities Division
Fort Rucker, Alabama 36362

PLEASE MAKE REMITTANCE TO

Andalusia Office

SERVICE ADDRESS
Fort Rucker DABTO-1-74-0153

DATE EXPLANATION OF CHARGE	AMOUNT
June 1992	
Meter Station #12405	
See analysis sheet for meter readings and consumption =29,638 Mcf.	
Meter Stations #12301 and #12302	
For daily consumption and meter readings see attached monthly meter analysis sheets: 0 Mcf.	
Commodity Charge:	
29,638 Mcf @ $2.691850 per Mcf	$79,781.05
Add Btu adjustment @ 2.19%	1,747.20
	81,528.25
Demand Charge:	
3,436 Mcf @ $8.952300 per Mcf	30,760.10
Balance due	$112,288.35
Average Btu content for the month was 1021.900.	
Billing Demand Mcf established January 16, 1992.	

I certify that this bill is correct and just; that payment therefor has not been received; that all statutory requirements as to American production and labor standards, and all conditions of purchase applicable to the transactions have been complied with and that State or local sales taxes are not included in the amounts billed.

By ________ Clerk

Sworn to and subscribed before me
this 7th day of July 1992

Notary Public

My Commission Expires Feb. 14, 1996

THE SOUTHEAST ALABAMA GAS DISTRICT
GAS CONTROL DEPT.

FORT RUCKER JUNE 1992

DATE PUT ON	TEMP	SP.GR.	BTU	EXT. FACTOR	12405 MCF	12301 INT.DIF	12301 COEFF.	MCF	12302 INT.DIF	12302 COEFF.	MCF	TOTAL DAY
01-Jun	0	0.570	1019	1.4082	1007	0	375.14	0	0	620.39	0	1007
02-Jun	0	0.572	1021	1.4058	1033	0	375.14	0	0	620.39	0	1033
03-Jun	0	0.570	1020	1.4082	1094	0	375.14	0	0	620.39	0	1094
04-Jun	0	0.572	1023	1.4058	1052	0	375.14	0	0	620.39	0	1052
05-Jun	0	0.572	1022	1.4058	886	0	375.14	0	0	620.39	0	886
06-Jun	0	0.572	1023	1.4058	980	0	375.14	0	0	620.39	0	980
07-Jun	0	0.572	1022	1.4058	933	0	375.14	0	0	620.39	0	933
08-Jun	0	0.571	1021	1.4070	1034	0	375.14	0	0	620.39	0	1034
09-Jun	0	0.571	1021	1.4070	1065	0	375.14	0	0	620.39	0	1065
10-Jun	0	0.571	1021	1.4070	1091	0	375.14	0	0	620.39	0	1091
11-Jun	0	0.571	1021	1.4070	1095	0	375.14	0	0	620.39	0	1095
12-Jun	0	0.570	1020	1.4082	1049	0	375.14	0	0	620.39	0	1049
13-Jun	0	0.571	1021	1.4070	1002	0	375.14	0	0	620.39	0	1002
14-Jun	0	0.571	1022	1.4070	926	0	375.14	0	0	620.39	0	926
15-Jun	0	0.571	1021	1.4070	970	0	375.14	0	0	620.39	0	970
16-Jun	0	0.571	1021	1.4070	987	0	375.14	0	0	620.39	0	987
17-Jun	0	0.572	1022	1.4058	999	0	375.14	0	0	620.39	0	999
18-Jun	0	0.572	1023	1.4058	990	0	375.14	0	0	620.39	0	990
19-Jun	0	0.572	1022	1.4058	891	0	375.14	0	0	620.39	0	891
20-Jun	0	0.572	1023	1.4058	860	0	375.14	0	0	620.39	0	860
21-Jun	0	0.572	1023	1.4058	934	0	375.14	0	0	620.39	0	934
22-Jun	0	0.572	1022	1.4058	1021	0	375.14	0	0	620.39	0	1021
23-Jun	0	0.572	1024	1.4058	1007	0	375.14	0	0	620.39	0	1007
24-Jun	0	0.573	1024	1.4046	1000	0	375.14	0	0	620.39	0	1000
25-Jun	0	0.572	1023	1.4058	993	0	375.14	0	0	620.39	0	993
26-Jun	0	0.572	1023	1.4058	973	0	375.14	0	0	620.39	0	973
27-Jun	0	0.572	1022	1.4058	959	0	375.14	0	0	620.39	0	959
28-Jun	0	0.571	1022	1.4070	888	0	375.14	0	0	620.39	0	888
29-Jun	0	0.572	1023	1.4058	936	0	375.14	0	0	620.39	0	936
30-Jun	0	0.572	1022	1.4058	983	0	375.14	0	0	620.39	0	983
*** TOTALS **		17.146	30657	********	29638	*******	*********	0	*******	*********	0	

AVERAGE BTU @ =1021.900	Off Reading --- 340591	TOTAL DELIVERY THIS CUSTOMER 29638
	On Reading ---- 310953	
PREPARED BY:		
	Total 12405 = 29638	

GO-181

THE SOUTHEAST ALABAMA GAS DISTRICT

POST OFFICE BOX 1330
ANDALUSIA, ALABAMA 36420

25-1002

DATE August 6, 1992

PLEASE MAKE REMITTANCE TO

Andalusia Office

LD TO

DEH
Building 1404
Utilities Division
Fort Rucker, Alabama 36362

SERVICE ADDRESS Fort Rucker DABTO-1-74-0153

DATE	EXPLANATION OF CHARGE	AMOUNT
	<u>July 1992</u>	
	<u>Meter Station #12405</u>	
	See analysis sheet for meter readings and consumption = 28,291 Mcf.	
	<u>Meter Stations #12301 and #12302</u>	
	For daily consumption and meter readings see attached monthly meter analysis sheets: 0 Mcf.	
	<u>Commodity Charge:</u>	
	28,291 Mcf @ $2.928320 per Mcf....................................	$ 82,845.10
	Add Btu adjustment @ 2.226%..	1,844.13
		84,689.23
	<u>Demand Charge:</u>	
	3,436 Mcf @ $9.011300 per Mcf......................................	30,962.83
	Balance due....	$115,652.06

Average Btu content for the month was 1022.26.

Billing Demand Mcf established January 16, 1992.

I certify that this bill is correct and just; that payment therefor has not been received; that all statutory requirements as to American production and labor standards, and all conditions of purchase applicable to the transactions have been complied with and that State or local sales taxes are not included in the amounts billed.

By ______ Clerk

Sworn to and subscribed before me this 6th day of August 1992

Notary Public

My Commission Expires Feb. 14, 1996

SOUTHERN NATURAL GAS COMPANY
FERC Gas Tariff
Sixth Revised Volume No. 1

One Hundred Twentieth Rev. Sheet No. 4A
Superseding One Hundred Nineteenth Rev. Sheet No. 4A

ORIGINAL PGA-1

Statement of Currently Effective Rates Applicable to Rate Schedules Contained in FERC GAS Tariff, Sixth Volume No. 1

SUMMER RATES (MARCH - NOVEMBER)

PER MCF AT 14.73 PSIA

Rate Schedule	Base Tariff Rates	Purchased Gas Current Adjustment	Purchased Gas Cumulative Adjustment	Purchased Gas Surcharge Adjustment	Rates After Adjustment	Volumetric TOP Surcharge	DCC Surcharge Adjustment	GRI Surcharge Adjustment	ACA Unit Charge	Rates to be Effective Aug. 1,1992
OCD-1										
Demand	$5.392	$0.000	($0.419)	$0.134	$5.107	-	-	-	-	$5.107
Commodity	322.599 ¢	(10.362)¢	(72.152)¢	4.400 ¢	254.847 ¢	7.666 ¢	(0.009)¢	1.470 ¢	0.230 ¢	264.204 ¢
Daily Demand	17.727 ¢	0.000 ¢	(1.378)¢	0.441 ¢	16.790 ¢	- ¢	- ¢	- ¢	- ¢	16.790 ¢
OCDL-1										
Demand	$5.392	$0.000	($0.419)	$0.134	$5.107	-	-	-	-	$5.107
Commodity	322.599 ¢	(10.362)¢	(72.152)¢	4.400 ¢	254.847 ¢	7.666 ¢	(0.009)¢	- ¢	0.230 ¢	262.734 ¢
Daily Demand	17.727 ¢	0.000 ¢	(1.378)¢	0.441 ¢	16.790 ¢	- ¢	- ¢	- ¢	- ¢	16.790 ¢
OCD-2										
Demand	$8.980	($0.003)	($0.696)	$0.134	$8.418	-	-	-	-	$8.418
Commodity	323.558 ¢	(10.362)¢	(72.152)¢	4.400 ¢	255.806 ¢	7.666 ¢	(0.009)¢	1.470 ¢	0.230 ¢	265.163 ¢
Daily Demand	29.523 ¢	(0.010)¢	(2.289)¢	0.441 ¢	27.675 ¢	- ¢	- ¢	- ¢	- ¢	27.675 ¢
OCD-3										
Demand	$9.428	($0.001)	($0.375)	$0.134	$9.187	-	-	-	-	$9.187
Commodity	328.456 ¢	(10.362)¢	(72.152)¢	4.400 ¢	260.704 ¢	7.666 ¢	(0.009)¢	1.470 ¢	0.230 ¢	270.061 ¢
Daily Demand	30.996 ¢	(0.003)¢	(1.233)¢	0.441 ¢	30.204 ¢	- ¢	- ¢	- ¢	- ¢	30.204 ¢
G-1	369.871 ¢	(10.362)¢	(75.826)¢	5.575 ¢	299.620 ¢	7.666 ¢	- ¢	1.470 ¢	0.230 ¢	308.986 ¢
G-2	402.287 ¢	(10.388)¢	(78.254)¢	5.575 ¢	329.608 ¢	7.666 ¢	- ¢	1.470 ¢	0.230 ¢	338.974 ¢
G-3	411.112 ¢	(10.371)¢	(75.441)¢	5.575 ¢	341.246 ¢	7.666 ¢	- ¢	1.470 ¢	0.230 ¢	350.612 ¢
AO-1	340.326 ¢	(10.362)¢	(73.530)¢	4.841 ¢	271.637 ¢	7.666 ¢	(0.009)¢	1.470 ¢	0.230 ¢	280.994 ¢
AOL-1	340.326 ¢	(10.362)¢	(73.530)¢	4.841 ¢	271.637 ¢	7.666 ¢	(0.009)¢	- ¢	0.230 ¢	279.524 ¢
AO-2	353.081 ¢	(10.372)¢	(74.441)¢	4.841 ¢	283.481 ¢	7.666 ¢	(0.009)¢	1.470 ¢	0.230 ¢	292.838 ¢
AO-3	359.452 ¢	(10.365)¢	(73.385)¢	4.841 ¢	290.908 ¢	7.666 ¢	(0.009)¢	1.470 ¢	0.230 ¢	300.265 ¢
EX-1	356.267 ¢	(10.368)¢	(73.913)¢	4.841 ¢	287.195 ¢	7.666 ¢	(0.009)¢	- ¢	0.230 ¢	295.082 ¢
Average Commodity Cost of Gas Supply per MCF at 1000 Btu										
Commodity	$3.05167	($0.10362)	($0.72152)							$2.33015 *

*Includes a commodity cost of gas, on a purchase basis, of $2.22974 plus fuel costs.
Estimated average commodity cost of gas in last scheduled PGA: 2.43377
Current Estimated average commodity cost of gas in latest PGA (rate currently being charged): 2.33015

Issued by: Greg P. Meyers, Vice-Pres. Rates
Issued on: JULY 29, 1992

Effective: AUGUST 01, 1992

THE SOUTHEAST ALABAMA GAS DISTRICT
GAS CONTROL DEPT.

FORT RUCKER JULY 1992

DATE PUT ON	TEMP	SP.GR.	BTU	EXT. FACTOR	12405 MCF	12301 INT.DIF	12301 COEFF.	MCF	12302 INT.DIF	12302 COEFF.	MCF	TOTAL DAY
01-Jul	0	0.572	1023	1.4058	930	0	375.14	0	0	620.39	0	930
02-Jul	0	0.572	1022	1.4058	757	0	375.14	0	0	620.39	0	757
03-Jul	0	0.570	1020	1.4082	893	0	375.14	0	0	620.39	0	893
04-Jul	0	0.572	1022	1.4058	774	0	375.14	0	0	620.39	0	774
05-Jul	0	0.571	1022	1.4070	857	0	375.14	0	0	620.39	0	857
06-Jul	0	0.571	1022	1.4070	860	0	375.14	0	0	620.39	0	860
07-Jul	0	0.572	1022	1.4058	887	0	375.14	0	0	620.39	0	887
08-Jul	0	0.572	1023	1.4058	903	0	375.14	0	0	620.39	0	903
09-Jul	0	0.575	1024	1.4021	911	0	375.14	0	0	620.39	0	911
10-Jul	0	0.571	1022	1.4070	859	0	375.14	0	0	620.39	0	859
11-Jul	0	0.572	1022	1.4058	801	0	375.14	0	0	620.39	0	801
12-Jul	0	0.572	1022	1.4058	881	0	375.14	0	0	620.39	0	881
13-Jul	0	0.572	1022	1.4058	958	0	375.14	0	0	620.39	0	958
14-Jul	0	0.572	1022	1.4058	975	0	375.14	0	0	620.39	0	975
15-Jul	0	0.572	1022	1.4058	962	0	375.14	0	0	620.39	0	962
16-Jul	0	0.574	1023	1.4033	993	0	375.14	0	0	620.39	0	993
17-Jul	0	0.572	1023	1.4058	954	0	375.14	0	0	620.39	0	954
18-Jul	0	0.571	1022	1.4070	840	0	375.14	0	0	620.39	0	840
19-Jul	0	0.571	1022	1.4070	879	0	375.14	0	0	620.39	0	879
20-Jul	0	0.572	1022	1.4058	979	0	375.14	0	0	620.39	0	979
21-Jul	0	0.571	1022	1.4070	950	0	375.14	0	0	620.39	0	950
22-Jul	0	0.572	1022	1.4058	965	0	375.14	0	0	620.39	0	965
23-Jul	0	0.573	1023	1.4046	1011	0	375.14	0	0	620.39	0	1011
24-Jul	0	0.572	1022	1.4058	922	0	375.14	0	0	620.39	0	922
25-Jul	0	0.572	1022	1.4058	823	0	375.14	0	0	620.39	0	823
26-Jul	0	0.572	1023	1.4058	904	0	375.14	0	0	620.39	0	904
27-Jul	0	0.572	1023	1.4058	1015	0	375.14	0	0	620.39	0	1015
28-Jul	0	0.572	1022	1.4058	1024	0	375.14	0	0	620.39	0	1024
29-Jul	0	0.572	1022	1.4058	967	0	375.14	0	0	620.39	0	967
30-Jul	0	0.572	1022	1.4058	973	0	375.14	0	0	620.39	0	973
31-Jul	0	0.573	1023	1.4046	884	0	375.14	0	0	620.39	0	884
<<< TOTALS <<		17.731	31690	<<<<<<<<	28291	<<<<<<<	<<<<<<<<<	0	<<<<<<<	<<<<<<<<<	0	

AVERAGE BTU @ 14.73 =1022.258	Off Reading --- 368882	TOTAL DELIVERY THIS CUSTOMER 28291
	On Reading ---- 340591	
PREPARED BY: [signature] 8-6-92	Total 12405 = 28291	

GD-151

THE SOUTHEAST ALABAMA GAS DISTRICT

POST OFFICE BOX 1338
ANDALUSIA, ALABAMA 36420

25-1002

DATE September 8, 1992

SOLD TO
DEH
Building 1404
Utilities Division
Fort Rucker, Alabama 36362

PLEASE MAKE REMITTANCE TO

Andalusia Office

SERVICE ADDRESS Fort Rucker DABTO-1-74-0153

DATE	EXPLANATION OF CHARGE	AMOUNT
	<u>August 1992</u>	
	<u>Meter Station #12405</u>	
	See analysis sheet for meter readings and consumption = 28,142 Mcf.	
	<u>Meter Stations #12301 and #12302</u>	
	For daily consumption and meter readings see attached monthly meter analysis sheets: 0 Mcf.	
	<u>Commodity Charge:</u>	
	28,142 Mcf @ $2.824700 per Mcf..	$ 79,492.71
	Add Btu adjustment @ 2.400%..	1,907.83
		81,400.54
	<u>Demand Charge:</u>	
	3,436 Mcf @ $9.008300 per Mcf..	30,952.52
	Balance due....	$112,353.06

Average Btu content for the month was 1024.00.

Billing Demand Mcf established January 16, 1992.

Sworn to and subscribed before me this 8th day of September 1992

Notary Public

My Commission Expires Feb. 14, 1996

I certify that this bill is correct and just; that payment therefor has not been received; that all statutory requirements as to American production and labor standards, and all conditions of purchase applicable to the transactions have been complied with and that State or local sales taxes are not included in the amounts billed.

By ______________ Clerk

THE SOUTHEAST ALABAMA GAS DISTRICT
GAS CONTROL DEPT.

FORT RUCKER AUGUST 1992

DATE PUT ON	TEMP	SP.GR.	BTU	EXT. FACTOR	12405 MCF	12301 INT.DIF	12301 COEFF.	MCF	12302 INT.DIF	12302 COEFF.	MCF	TOTAL DAY
01-Aug	0	0.573	1023	1.4046	800	0	375.14	0	0	620.39	0	800
02-Aug	0	0.572	1023	1.4058	946	0	375.14	0	0	620.39	0	946
03-Aug	0	0.570	1020	1.4082	1092	0	375.14	0	0	620.39	0	1092
04-Aug	0	0.571	1021	1.4070	1097	0	375.14	0	0	620.39	0	1097
05-Aug	0	0.569	1020	1.4095	594	0	375.14	0	0	620.39	0	594
06-Aug	0	0.569	1019	1.4095	961	0	375.14	0	0	620.39	0	961
07-Aug	0	0.570	1021	1.4082	907	0	375.14	0	0	620.39	0	907
08-Aug	0	0.570	1021	1.4082	806	0	375.14	0	0	620.39	0	806
09-Aug	0	0.572	1024	1.4058	880	0	375.14	0	0	620.39	0	880
10-Aug	0	0.571	1022	1.4070	953	0	375.14	0	0	620.39	0	953
11-Aug	0	0.571	1022	1.4070	965	0	375.14	0	0	620.39	0	965
12-Aug	0	0.570	1021	1.4082	954	0	375.14	0	0	620.39	0	954
13-Aug	0	0.569	1020	1.4095	1024	0	375.14	0	0	620.39	0	1024
14-Aug	0	0.570	1021	1.4082	884	0	375.14	0	0	620.39	0	884
15-Aug	0	0.572	1023	1.4058	796	0	375.14	0	0	620.39	0	796
16-Aug	0	0.571	1021	1.4070	895	0	375.14	0	0	620.39	0	895
17-Aug	0	0.570	1021	1.4082	979	0	375.14	0	0	620.39	0	979
18-Aug	0	0.569	1020	1.4095	933	0	375.14	0	0	620.39	0	933
19-Aug	0	0.570	1021	1.4082	935	0	375.14	0	0	620.39	0	935
20-Aug	0	0.571	1022	1.4070	939	0	375.14	0	0	620.39	0	939
21-Aug	0	0.568	1019	1.4108	853	0	375.14	0	0	620.39	0	853
22-Aug	0	0.569	1020	1.4095	770	0	375.14	0	0	620.39	0	770
23-Aug	0	0.571	1022	1.4070	867	0	375.14	0	0	620.39	0	867
24-Aug	0	0.571	1022	1.4070	934	0	375.14	0	0	620.39	0	934
25-Aug	0	0.570	1021	1.4082	935	0	375.14	0	0	620.39	0	935
26-Aug	0	0.581	1025	1.3948	970	0	375.14	0	0	620.39	0	970
27-Aug	0	0.582	1024	1.3936	995	0	375.14	0	0	620.39	0	995
28-Aug	0	0.588	1033	1.3865	873	0	375.14	0	0	620.39	0	873
29-Aug	0	0.591	1041	1.3830	803	0	375.14	0	0	620.39	0	803
30-Aug	0	0.592	1049	1.3818	906	0	375.14	0	0	620.39	0	906
31-Aug	0	0.583	1042	1.3925	896	0	375.14	0	0	620.39	0	896
*** TOTALS **		17.776	31744	********	28142	*******	*********	0	*******	*********	0	

AVERAGE BTU @ 14.73 =1024.000	Off Reading --- 397024	TOTAL DELIVERY THIS CUSTOMER 28142
	On Reading ---- 368882	
PREPARED BY: 9-7-92	Total 12405 = 28142	

4.0 ENERGY CONSERVATION OPPORTUNITY: COOLING STORAGE SYSTEM FOR PEAK DEMAND REDUCTION

4.1 Existing Conditions

The Lyster Army Community Hospital is presently cooled by chilled water provided by three centrifugal chillers located in the main mechanical room in the building. The total plant capacity is 820 tons with two 230 ton chillers and one 360 ton chiller. These chillers are presently manually staged by operating personnel to meet building loads.

As part of the Energy Engineering Analysis Program performed in 1989 in the Lyster Army Community Hospital, ECO 2 was identified to convert this chilled water plant from constant chilled water flow to variable water flow utilizing primary-secondary chilled water loops. A copy of this ECO is included in Appendix 4A of this section for review. Personnel at Fort Rucker have indicated that this ECO has been selected for implementation and designs have been completed with funding yet to be committed to the project. The considerations contained in this new study are based on the assumption that a cooling storage system would be interfaced with this plant following the implementation of the primary-secondary chilled water pumping system. It should also be noted that this modification is necessary in order to facilitate the most functional use of the proposed cooling storage system.

4.2 Rate And Demand Considerations

Fort Rucker is provided electrical energy by Alabama Power Company as a municipal customer under Rate Schedule MR-1. Service is provided to Fort Rucker at transmission voltage of 115 KV. Charges for service are as follows:

Billing Demand	-	$10.09 per KVA
Energy	-	$0.0215 per KWH

The electrical rate applicable to the base is also subject to a 75% ratchet of peak summer demands. A peak demand occurring during the months of June through October result in a minimum billed demand for the following eleven months of 75% of that peak. For example, the electrical billing history of the base included in this section shows the peak summer demand at the base occurring in July, 1991 was 28,800 KVA. Based on the 75% ratchet, a minimum billed demand for the following eleven months would be 21,600 KVA. This feature of the electrical rate is significant in evaluating the economic impact of cooling storage at the hospital.

The following is a history of demands, energy use and cost for the electrical service to Fort Rucker for the twelve month period beginning July, 1991 through June, 1992. A copy of the applicable rate schedule and billing history is included in Appendix 4B of this ECO section.

TABLE 4.1: FORT RUCKER ELECTRICAL BILLING HISTORY

MONTH	ACTUAL DEMAND (KVA)	BILLED DEMAND (KVA)	CONSUMPTION (KWH)	TOTAL COST ($)
JUL 1991	28,800	28,800	12,936,000	537,460
AUG 1991	28,656	28,656	14,136,000	559,904
SEP 1991	28,627	28,627	13,104,000	539,060
OCT 1991	27,936	27,936	9,816,000	445,832
NOV 1991	21,225	21,600	8,808,000	367,513
DEC 1991	16,704	21,600	7,896,000	354,644
JAN 1992	16,588	21,600	7,344,000	344,239
FEB 1992	16,473	21,600	7,920,000	355,095
MAR 1992	16,963	21,600	7,368,000	373,109
APR 1992	21,772	21,772	7,776,000	377,678
MAY 1992	25,776	25,776	9,672,000	456,600
JUN 1992	26,496	26,496	11,592,000	491,756
TOTALS			118,368,000	$5,202,890

Another significant factor regarding the applicable electric rate at Fort Rucker to the utilization of cooling storage for demand control is the fact that there is no time of day rate incentive for off peak power use. Demand rates remain constant at all times of the day. Alabama Power Company, however, is presently developing a time of day rate to encourage off peak power use. They anticipate that this new rate will be available to their large commercial and industrial customers within the next year. Present indications are, however, that this rate will not be available for municipal customers at this time due to the already low energy pricing. The fact that this new rate will be offered by Alabama Power Company is cause for energy managers at Fort Rucker to monitor the situation closely to determine if it can be advantageous. Such a rate would certainly make off peak cooling storage more economically attractive.

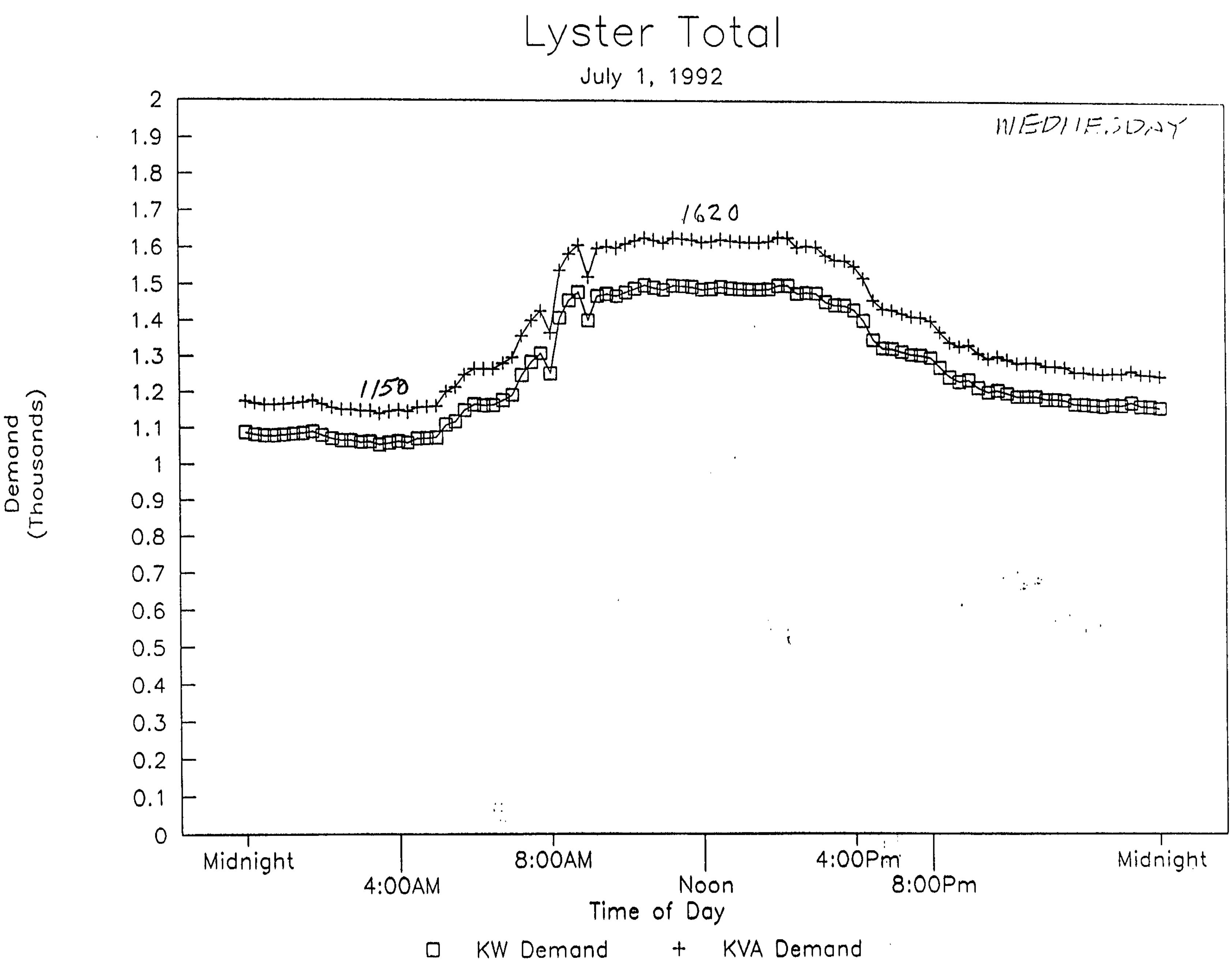
4.2.1 Hospital Metering

Lyster Army Community Hospital has owner installed electrical sub-metering equipment to interface with the Building Automation System so that demand control strategies may be implemented by building operators. As a part of this study, this metering equipment was utilized to do a 24 hour demand profile for a period of 10 days in the peak cooling period last summer. The purpose of this sub-metering was to assess the diversity of load over a peak 24 hour period to determine if there was an opportunity to levelize the load with cooling storage and reduce the peak connected load of the hospital. These meters are not used for billing purposes by Alabama Power Company.

Figure 4.1 shown on the following page indicates the load profile of the hospital for a typical peak cooling day. The load profiles for the total ten days of metering is included in Appendix 4C of this ECO section.

This data indicates that the 24 hour load profile of the hospital is relatively level with high off peak loads. The swing in loads from on peak to off peak ranges from 400 to 500 KVA. This provides little opportunity within the hospital to incorporate a load shifting strategy for demand control.

FIGURE 4.1 LYSTER ARMY COMMUNITY HOSPITAL PEAK SUMMER DAY DEMAND PROFILE



4.2.2 Base Metering

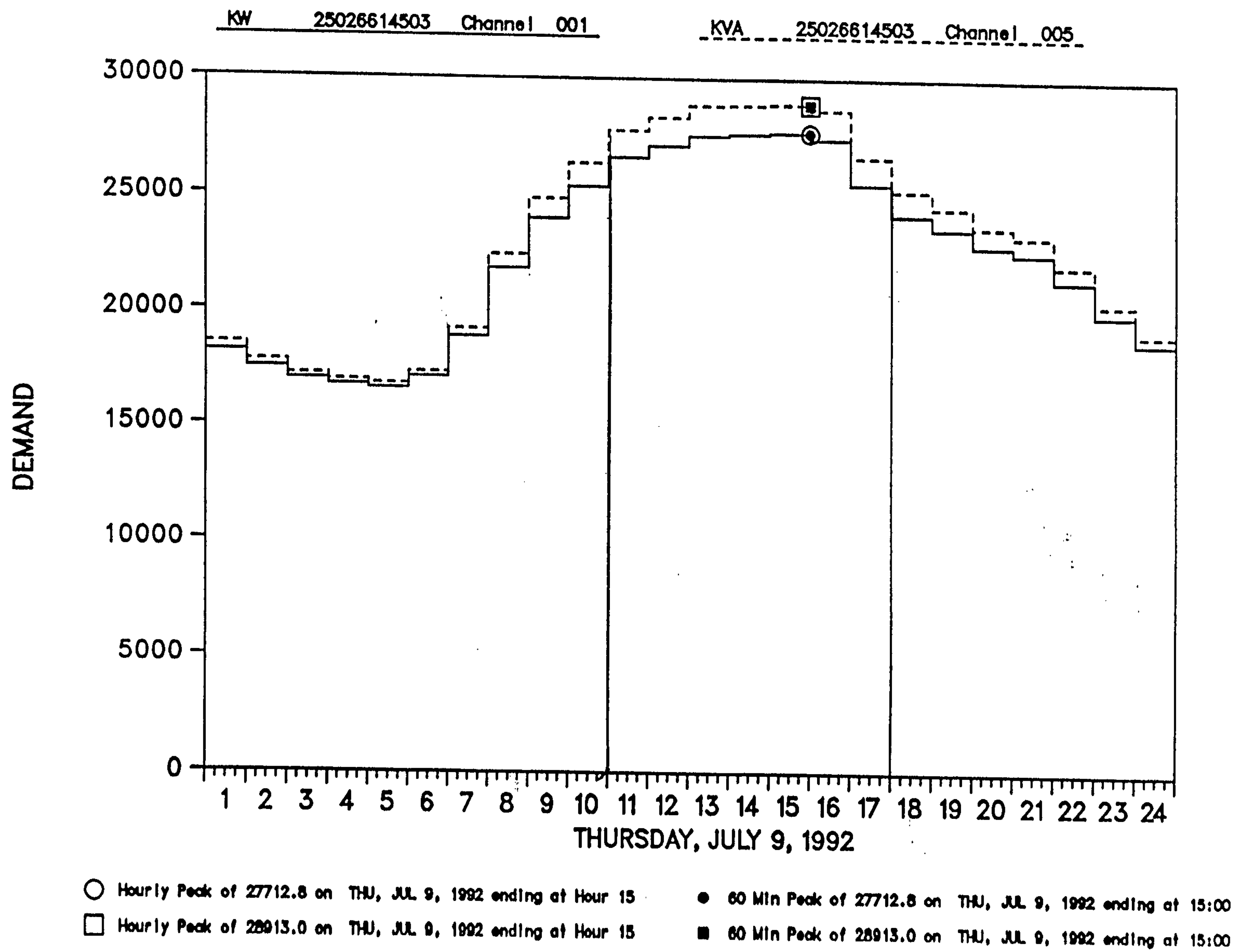
Similar metering of the main electrical service to Fort Rucker indicated a very different situation. The peak electrical load during the past year was set on Thursday, July 9, 1992 at 28,913 KVA at 1,500 hours. The off peak minimum load during that same day was 16,582 KVA set at 0400 hours. The swing in the daily load of 12,331 KVA provides a significant opportunity for a load shifting strategy for demand control. It should also be noted that the peak demand recorded on this date set the ratcheted minimum billed demand for the next eleven months at 21,600 KVA. Figure 4.2 and Table 4.2 on the following pages depict the loads during this peak day in tabular and graphical form.

Based on this information and the fact that anything done at the hospital to reduce connected electrical loads during this peak period will reduce base demand charges provides adequate basis to pursue a cooling storage strategy.

FIGURE 4.2 APCO PEAK SUMMER DAY ELECTRICAL DEMAND GRAPH

US ARMY AVIATION CENTER

JCT
APCo Load Research



Dec 2,1992 4:01:51 pm

TABLE 4.2 APCO PEAK SUMMER DAY ELECTRICAL DEMAND DATA

REPORT ID: LRARIN-1 OPER NUM: 0070 APCO KW/KVA/KVAR POWER FACTOR REPORT TEST ID: 25028814503 RUN DATE 11/22/92
ANALYSIS : FT RUCKER -MG US ARMY AVIATION CENTER CHANS: 001-A-000 KW 002-A-000 KVAR PAGE 91
OPERATION LABEL : PF-01 DALEVILLE DPR : 7.200000 7.200000

	MON	07/06/92		TUE	07/07/92		WED	07/08/92		THU	07/09/92		FRI	07/10/92		SAT	07/11/92		SUN	07/12/92	
HOUR	KW	KVA	%PF	KW	KVA	%PF	KW	KVA	%PF	KW	KVA	%PF	KW	KVA	%PF	KW	KVA	%PF	KW	KVA	%PF
1:00	14702	14734	100	15984	16130	99	17165	17401	99	18166	18536	98	17971	18332	98	15509	15528	100	15084	15095	100
2:00	14371	14413	100	15530	15660	99	16728	16921	99	17467	17780	98	17316	17615	98	14861	14864	100	14501	14502	100
3:00	14141	14179	100	15077	15177	99	16135	16294	99	16970	17198	99	16855	17123	98	14321	14321	100	14278	14278	100
4:00	14198	14241	100	14854	14937	99	15890	16055	99	16726	16948	99	16603	16838	99	13975	13975	100	13954	13954	100
5:00	14249	14290	100	14947	15008	100	15869	16020	99	16582	16790	99	16603	16829	99	13673	13673	100	13594	13594	100
6:00	14810	14859	100	15350	15415	100	16315	16479	99	17078	17304	99	17050	17288	99	13356	13356	100	13342	13342	100
7:00	16488	16601	99	16697	16814	99	17683	17911	99	18864	19204	98	18238	18538	98	13255	13255	100	13126	13126	100
8:00	19390	19687	98	19706	20022	98	20887	21378	98	21845	22432	97	21370	21941	97	13788	13788	100	13586	13586	100
9:00	21247	21680	98	22154	22712	98	23191	23896	97	23990	24837	97	23710	24503	97	14933	14933	100	14551	14551	100
10:00	22068	22608	98	23702	24421	97	24826	25764	96	25344	26357	96	25020	25969	96	16322	16331	100	15926	15934	100
11:00	21938	22412	98	25135	26066	96	25877	26919	96	26597	27778	96	26064	27193	96	17539	17584	100	17244	17285	100
12:00	21658	21937	99	25970	27018	96	26474	27536	96	27115	28341	96	26734	27941	96	18562	18667	99	18230	18330	99
13:00	24048	24640	98	26474	27594	96	26964	28089	96	27576	28842	96	27115	28441	95	19238	19385	99	19044	19190	99
14:00	25445	26405	96	26834	27950	96	27432	28615	96	27655	28856	96	27230	28537	95	19440	19602	99	19368	19535	99
15:00	25862	26881	96	26870	28023	96	27526	28753	96	27713	28913	96	27137	28449	95	19771	19968	99	19490	19680	99
16:00	25546	26508	96	26338	27411	96	27367	28594	96	27432	28669	96	26453	27719	95	19728	19919	99	19814	20017	99
17:00	23270	24045	97	24545	25423	97	25459	26541	96	25488	26650	96	24278	25279	96	19670	19857	99	18742	18889	99
18:00	22018	22718	97	23227	24070	96	24012	24969	96	24178	25219	96	23011	23867	96	19440	19614	99	17482	17563	100
19:00	21319	21968	97	22291	23020	97	23177	24020	96	23573	24494	96	22277	22981	97	18929	19092	99	16675	16711	100
20:00	20484	20969	98	21686	22319	97	22558	23336	97	22831	23662	96	21442	22073	97	18209	18330	99	15934	15943	100
21:00	20153	20533	98	21427	21992	97	22169	22836	97	22522	23254	97	20621	21054	98	18158	18263	99	15869	15875	100
22:00	19238	19592	98	20556	21077	98	21398	22024	97	21370	22009	97	19505	19761	99	17561	17636	100	15509	15512	100
23:00	17806	18067	99	19231	19640	98	20088	20595	98	19872	20358	98	17971	18110	99	16812	16868	100	15214	15232	100
24:00	16718	16908	99	18173	18485	98	18994	19422	98	18684	19058	98	16488	16529	100	15890	15921	100	15070	15106	100
KWH	471167			502758			524182			535638			517062			402940			385627		
KVAH		480873			516382			540365			553487			532910			404730			386830	
PF			98			97			97			97			97			100			100

28,913 KVA
− 26,650 KVA
2,263 KVA

LOAD VARIATION
11:00AM TO 4:00PM

4.3 Cooling Storage System Type

The existing chilled water cooling system in Lyster Army Community Hospital makes chilled water storage the logical choice for the system to be evaluated. Preliminary economic analysis indicates that the savings potential for demand reduction will not justify duplication of refrigeration equipment as would be required with ice storage. In addition, space for a chilled water storage tank is readily available in reasonable proximity of the mechanical room outside the hospital.

Further, Technical Note No. 5-670-1, entitled "Lessons From Field Demonstrations And Testing Of Storage Cooling Systems" dated 16 April 1992 distributed by Department of the Army, Facilities Engineering, provides system selection criteria that would support this choice. A copy of this technical note is included in Appendix 4D of this ECO section for reference.

4.4 Load And Storage Analysis

The Trane TRACE program was utilized to establish the hourly cooling demand for a design day for each month of the year for the Lyster Army Community Hospital. Input to develop this data was extracted from the Trace Analysis included in the original 1989 study of this facility, verified, and re-entered into the program to perform this specific analysis. Output from this analysis is included in Appendix 4E of this ECO section.

The hourly cooling demand data identified the peak cooling day for the year in the hospital occurring during the month of August. The total cooling required during this 24 hour day is 9,046.1 ton-hours. At the present time, the chiller plant is producing most of this capacity during peak cooling hours which correspond to the Base peak electrical load period. Numerous strategies were evaluated with this data to examine means of shifting a portion of this load through chilled water storage to reduce the peak demand at the base electrical meter. This analysis showing storage strategies ranging from 6 to 12 off peak storage hours is included in this study in Appendix 4F in this ECO section.

4.4.1 Storage Strategy

Analysis of 24 hour load profiles on peak days for the base indicates that the peak occurs at 1400 hours. Load shedding that could occur during the six hour period from 1100 hours to 1700 hours would have approximately 2200 KVA of connected load to work with, far in excess of shedding potential from the chiller plant at the hospital. For this reason a storage strategy was selected to meet the total cooling requirements of the hospital during this six hour period. The peak storage requirement occurring in August is 3078.9 ton-hours and the system selected for this ECO is based on this criteria.

This selection results in the smallest possible storage tank to achieve the optimum demand reduction. The total cost benefit occurs from the reduction of peak demand during the peak month and the associated reduction in other months due to the 75% ratchet. The following tabulation, Table 4.3, indicates the anticipated reduction in connected loads for each month due to the chiller plant not operating during the six hour on-peak period. The KW values shown were extracted from TRACE data as the monthly connected loads for each chiller. Note the storage system is not utilized during the winter months since monthly base demands were already below ratcheted minimums and there was no further benefit to be realized. The TRACE data showing chiller KW data is included in Appendix 4G of this ECO section.

TABLE 4.3: MONTHLY DEMAND SAVINGS FOR COOLING THERMAL STORAGE

MONTH	CHILLER #1 (KW)	CHILLER #2 (KW)	CHILLER #3 (KW)	TOTAL SAVINGS (KW)
JAN	0.0	0.0	0.0	0.0
FEB	0.0	0.0	0.0	0.0
MAR	0.0	0.0	0.0	0.0
APR	176.6	187.9	0.0	364.5
MAY	177.5	232.0	0.0	409.5
JUN	190.3	246.9	35.7	472.9
JUL	194.6	251.7	37.8	484.1
AUG	193.8	253.0	0.0	446.8
SEP	179.4	239.8	33.5	452.7
OCT	168.6	139.5	0.0	308.1
NOV	155.0	0.0	0.0	155.0
DEC	0.0	0.0	0.0	0.0
TOTAL				3,093.6

There should be a nominal reduction in the energy consumption of the chillers operating during cooler night time hours. These reductions are likely to be offset by thermal losses in the chilled water storage system. For this reason, only the savings achieved by demand reductions are considered in this analysis. It should be anticipated, however, that once this system performance in optimized by experience, the total electrical cost reductions will exceed the projections in this study.

4.5 Cooling Storage System

The chilled water cooling storage system selected for this ECO is based on the utilization of the concept of thermally stratified chilled water. Thermally stratified systems take advantage of the tendency of water to separate into horizontal layers by density, a temperature-dependent characteristic. Under proper conditions, density differences create a temperature gradient region - a thermocline - that forms a barrier between warm and cold water. This greatly simplifies the withdrawal and charging processes. In recent years a great deal of research and development has been performed on this thermal storage concept and a number of systems are operating very successfully. Reliable design information is now available from several sources such as the Electric Power Research Institute.

Two documents that were helpful in developing this conceptual information are "Stratified Chilled Water Storage Design Guide" developed for the Electric Power Research Institute, and a paper entitled "Chilled Water Storage" authored by E. Ian Mackie, P.E. This paper is included in Appendix 4H of this section. The design guide can be made available.

4.5.1 Sizing

Based on the established peak storage requirement of 3,078.9 ton-hours and a consideration that an estimated 10% of the volume is not usable, the total storage capacity for this system should be approximately 3,500 ton-hours. The current chilled water discharge temperature from the chiller plant of 42°F will be maintained for storage. It will be assumed for the purposes of this study that water is returning from storage at 54°F for a 12°F average temperature difference. Therefore, the volume of the storage tank is calculated as follows:

$$\text{VOLUME (Gallons)} = \frac{\text{Load (BTU)}}{8.33\ \text{lbs/gal} \times \text{Specific Heat} \times \text{Avg. Temp. Difference}}$$

$$\text{VOLUME (Gallons)} = \frac{3{,}500 \times 12{,}000}{8.33 \times 1.0 \times 12}$$

$$\text{VOLUME (Gallons)} = 420{,}000\ \text{Gallons}$$

4.5.2 Conceptual Design

The proposed system will consist of an insulated steel tank 30' in height and 60' in diameter located above grade on the west side of the hospital directly opposite the cooling towers and in the vicinity of the mechanical equipment room as shown on Figure 4.3. The tank will include appropriate inlet diffusers to prevent turbulence and maintain the temperature gradient.

The principal consideration in the selection of a design concept utilizing a steel storage tank above ground was economic. This concept allowed the lowest possible first cost for the system. The above ground tank permits the chilled water levels in the tank and in the building to be hydrostatically equal so an isolating heat exchanger is not required. A tank below grade would double the tank cost and require an isolating heat exchanger. Also, a concrete tank would double the tank cost with the benefit of reduced maintenance. A steel tank will require periodic draining to coat interior surfaces for corrosion control.

As previously discussed in this study, the primary-secondary variable pumping chilled water ECO defined in the 1989 study should be implemented if this cooling storage ECO is considered. This will facilitate the best interface of the cooling storage with the chilled water plant.

Based on this arrangement, the cooling storage charging and discharging cycles will be accomplished as follows:

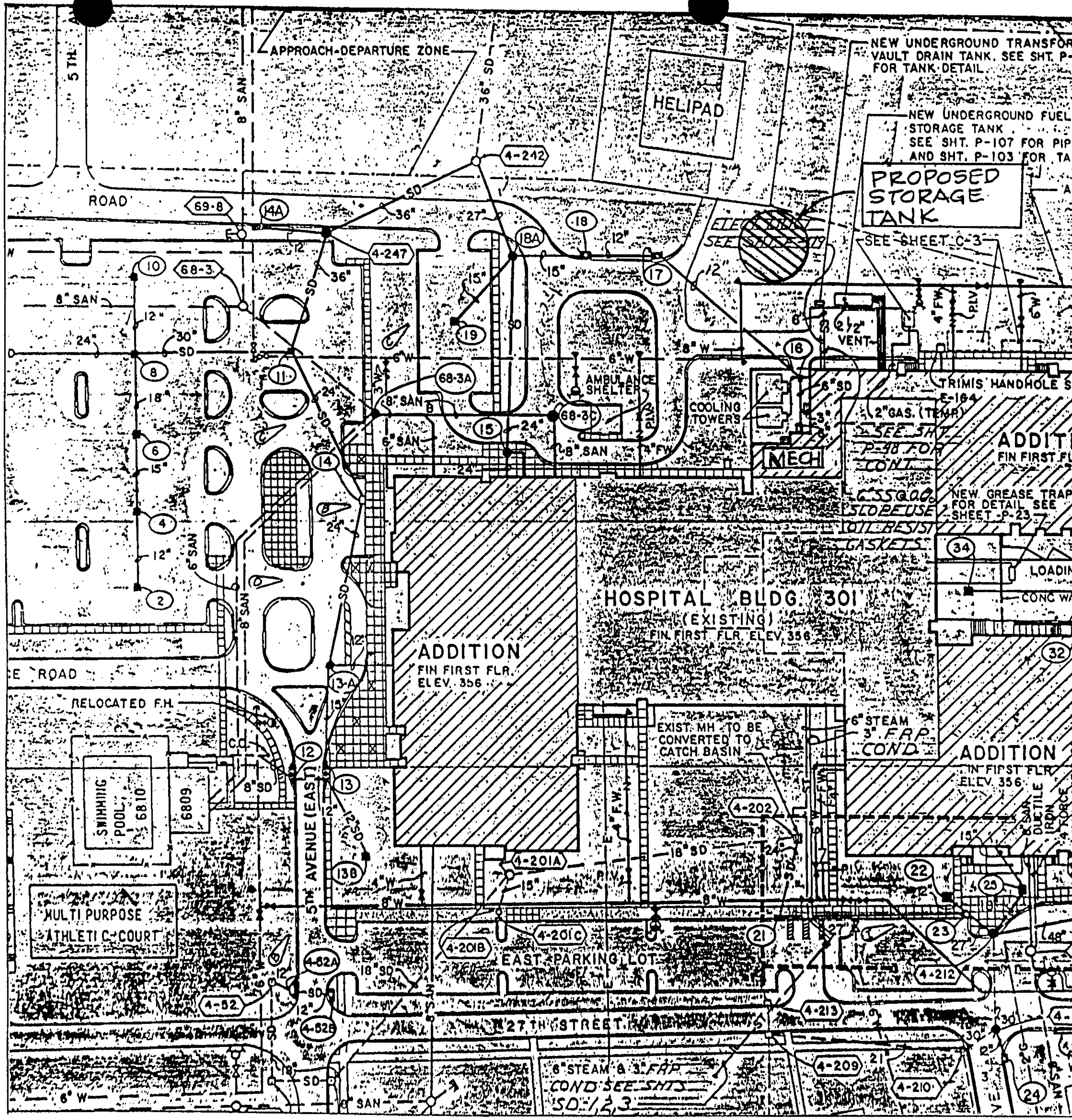
<u>Charging Cycle - Off Peak (See Figure 4.4)</u>

Chiller plant will be in operation with chillers and pumps staged to meet required building load and programmed storage requirements for the following day. Pumps P-4, P-5 and P-6 will be modified to maintain design flow with the additional head required to charge the storage tank and supply the secondary loop. The three-way valve will modulate to control necessary flow to the building and storage.

<u>Discharging Cycle - On Peak (See Figure 4.5)</u>

Chiller plant will not operate. Total building cooling load will be satisfied from storage. Pumps P-1, P-2 and P-3 will be staged to satisfy building cooling requirements. The three-way valve will be fully open to the storage.

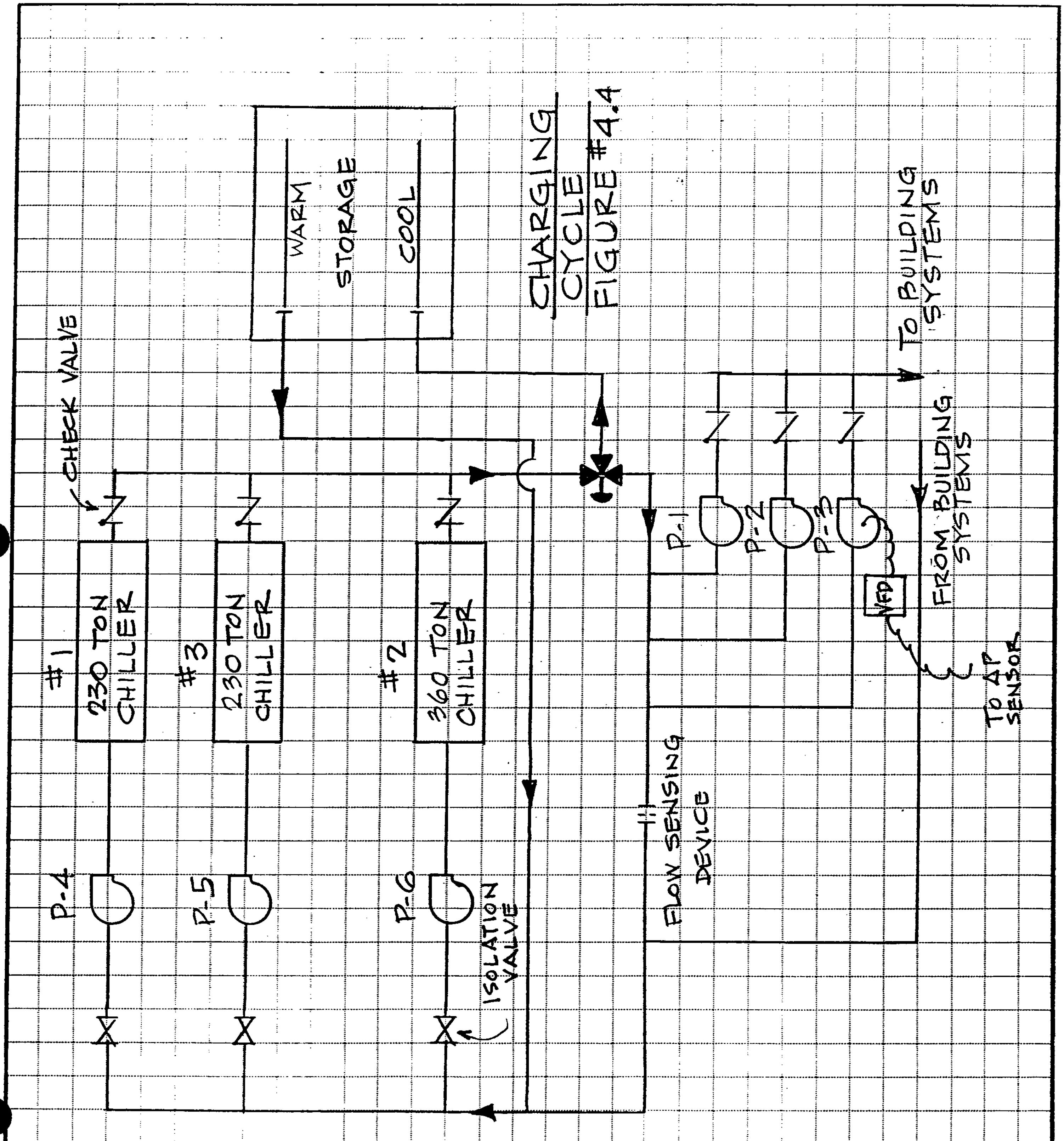
The cooling storage system will be interfaced with the existing building automation system to control charging and discharging rates based on predicted cooling loads and storage monitoring.



HOSPITAL SITE PLAN
SHOWING PROPOSED
STORAGE TANK LOCATION
SCALE 1/2" = 60'
FIGURE 4.3

ENGINEERING RESOURCE GROUP, INC.
P.O. Box 360687
BIRMINGHAM, AL 35236
(205) 985-9090

JOB: COOLING STORAGE LYSTER ARMY HOSPITAL
SHEET NO. ______ OF ______
CALCULATED BY: JACKINS DATE: 3/1/93
CHECKED BY: ______ DATE: ______
SCALE: NTS



JOB COOLING STORAGE LYSTER ARMY HOSPITAL

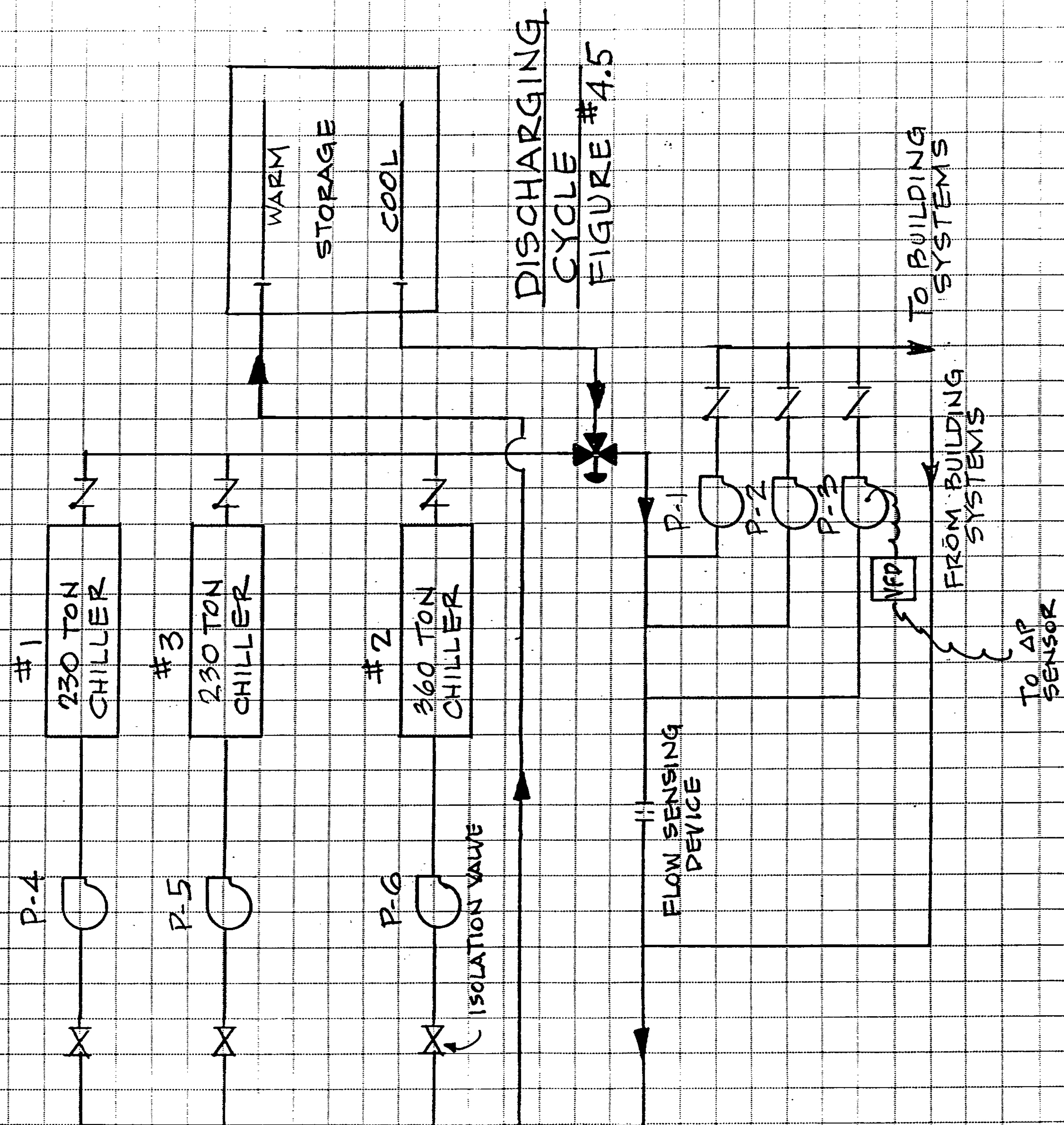
ENGINEERING RESOURCE GROUP, INC.
P.O. Box 360687
BIRMINGHAM, AL 35236
(205) 985-9090

SHEET NO. ________ OF ________

CALCULATED BY JACKINS DATE 3/1/93

CHECKED BY ________ DATE ________

SCALE NTS



4.5.3 Cost Of System

Cost estimates for the addition of the storage tank, insulation and diffuser were developed from discussions with vendors and others who had developed similar information. An estimated cost of $50.00 per ton-hour was mentioned in the paper "Chilled Water Storage" and this is comparable to costs established in the following estimate. Vendor information and cost estimates are included as Appendix 4I in this section. Other cost information was developed utilizing 1993 Means Cost Data.

Based on these estimates the total cost to add stratified chilled water storage to the Lyster Army Community Hospital following the implementation of the Variable Pumping ECO in the 1989 study will be $303,878.00.

4.5.4 Projected Savings

Savings resulting from the implementation of Cooling Storage at Lyster Army Community Hospital are shown in Table 4.4 following the cost estimate forms. These savings are calculated using the base cost of $10.09 per KVA saved. The reduction in KVA recorded by the Base meter is shown each month with the impact of the 75% demand ratchet included. The total annual savings are projected to be $47,964.

COST ESTIMATE ANALYSIS

For use of this form, see TM 5-800-2; the proponent agency is USACE.

PROJECT: COOLING THERMAL STORAGE SYSTEM	INVITATION/CONTRACTOR	EFFECTIVE PRICING DATE: 3/93	DATE PREPARED
LOCATION: LYSTER ARMY COMMUNITY HOSPITAL	CODE (Check one) ☐ A ☐ B ☐ C ☐ OTHER ____	DRAWING NO.	SHEET 1 OF 2 SHEETS
		ESTIMATOR	CHECKED BY

TASK DESCRIPTION	QUANTITY		LABOR				EQUIPMENT		MATERIAL		TOTAL	SHIPPING	
	NO. OF UNITS	UNIT MEAS	MH UNIT	TOTAL HRS	UNIT PRICE	COST	UNIT PRICE	COST	UNIT PRICE	COST		UNIT WT	TOTAL WT
420,000 GALLON													
STEEL, GROUND LEVEL													
STORAGE TANK	1	EACH									160,000		
INSULATION	1	JOB									37,270		
DIFFUSER	1	EACH									21,000		
SITE PREPARATION													
AND FOUNDATIONS	1	JOB									30,000		
UPGRADE CHILLER													
PUMPING SYSTEM	1	JOB									7,500		
(CONTINUED)													
TOTAL THIS SHEET													

DA FORM 5418-R, Apr 85

COST ESTIMATE ANALYSIS

For use of this form, see TM 5-800-2; the proponent agency is USACE.

PROJECT: Cooling Thermal Storage System	INVITATION/CONTRACTOR	EFFECTIVE PRICING DATE: 3/93	DATE PREPARED
LOCATION: Lyster Army Community Hospital	CODE (Check one) ☐ A ☐ B ☐ C ☐ OTHER	DRAWING NO. / ESTIMATOR	SHEET 2 OF 2 SHEETS / CHECKED BY

TASK DESCRIPTION	QUANTITY: NO. OF UNITS	QUANTITY: UNIT MEAS	LABOR: MH UNIT	LABOR: TOTAL HRS	LABOR: UNIT PRICE	LABOR: COST	EQUIPMENT: UNIT PRICE	EQUIPMENT: COST	MATERIAL: UNIT PRICE	MATERIAL: COST	TOTAL	SHIPPING: UNIT WT	SHIPPING: TOTAL WT
400′ – 6″ Diameter													
Steel Piping With													
Fittings	400	L.F.			17.05	6,820	1.27	508	15.70	6,280	13,608		
Interface With BAS													
– Control Value	1	EACH									4,500		
– 30 Control Points	30	EACH							750	22,500	22,500		
Miscellaneous													
Mechanical And													
Electrical	1	JOB									7,500		
Note: Total Costs													
Include Labor													
TOTAL THIS SHEET											303,878		

DA FORM 5418-R, Apr 85

TABLE 4.4: PROJECTED COST SAVINGS FOR COOLING STORAGE AT LYSTER ARMY COMMUNITY HOSPITAL

MONTH	ACTUAL BASE KW (BEFORE)	BILLED BASE KW (BEFORE)	BASE KW COST (BEFORE)	HOSPITAL SAVINGS (KW)	ACTUAL BASE KW (AFTER)	BILLED BASE KW (AFTER)	BASE KW COST (AFTER)	BASE METER KW COST SAVINGS
JAN	16,588	21,600	$217,944	0.0	16,588.0	21,237.0	$214,281	$3,663
FEB	16,473	21,600	$217,944	0.0	16,473.0	21,237.0	$214,281	$3,663
MAR	16,963	21,600	$217,944	0.0	16,963.0	21,237.0	$214,281	$3,663
APR	21,772	21,772	$219,679	364.5	21,407.5	21,407.5	$216,002	$3,678
MAY	25,776	25,776	$260,080	409.5	25,366.5	25,366.5	$255,948	$4,132
JUN	26,496	26,496	$267,345	472.9	26,023.1	26,023.1	$262,573	$4,772
JUL	28,800	28,800	$290,592	484.1	28,315.9	28,315.9	$285,707	$4,885
AUG	28,656	28,656	$289,139	446.8	28,209.2	28,209.2	$284,631	$4,508
SEP	28,627	28,627	$288,846	452.7	28,174.3	28,174.3	$284,279	$4,568
OCT	27,936	27,936	$281,874	308.1	27,627.9	27,627.9	$278,766	$3,109
NOV	21,225	21,600	$217,944	155.0	21,070.0	21,237.0	$214,281	$3,663
DEC	16,704	21,600	$217,944	0.0	16,704.0	21,237.0	$214,281	$3,663
TOTAL								$47,964

4.6 ECIP Documentation And DD Form 1391

Since this project has an estimated cost exceeding $300,000, it may qualify for the Energy Conservation Investment Program (ECIP). The project Life Cycle Cost Analysis indicates the following:

Annual Savings, KVA Demand	-	3,093.6
Annual Cost Savings	-	$47,964
Total Investment	-	$338,824
Simple Payback	-	7.06 Years
Total Net Discounted Savings	-	$651,831
Savings To Investment Ratio (SIR)	-	1.92
Adjusted Internal Rate Of Return (AIRR)	-	7.45%

Based on this analysis, the project meets the other requirements to be recommended as an ECIP project since the simple payback is less than eight years and the savings to investment ratio is greater than 1.0.

On this basis, programming documentation consisting of DD Form 1391 and life cycle cost analysis summary sheets are included in this section.

LIFE CYCLE COST ANALYSIS SUMMARY
ENERGY CONSERVATION INVESTMENT PROGRAM (ECIP)

LOCATION: Ft. Rucker REGION NO. 3 PROJECT NO. 2392
PROJECT TITLE: Limited Energy Studies FISCAL YEAR 1993
DISCRETE PORTION NAME: Cooling Thermal Storage
ANALYSIS DATE: 3/11/93 ECONOMIC LIFE 20 PREPARER Jackins

1. INVESTMENT COSTS:

A.	CONSTRUCTION COST	$ 303,878		
B.	SIOH	$ 16,713		
C.	DESIGN COST	$ 18,233		
D.	TOTAL COST (1A+1B+1C)	$ 338,824		
E.	SALVAGE VALUE OF EXISTING EQUIPMENT		$ 0	
F.	PUBLIC UTILITY COMPANY REBATE		$ 0	
G.	TOTAL INVESTMENT (1D-1E-1F)			$ 338,824

2. ENERGY SAVINGS (+)/COST(-):
DATE OF NISTIR 85-3273-X USED FOR DISCOUNT FACTORS Oct 1992

ENERGY SOURCE	COST $/MBTU(1)	SAVING MBTU/YR(2)	ANNUAL $ SAVINGS(3)	DISCOUNT FACTOR(4)	DISCOUNTED SAVINGS(5)
A. ELEC	$		$		$
B. DIST	$		$		$
C. RESID	$		$		$
D. NG	$		$		$
E. PPG	$		$		$
F. COAL	$		$		$
G. SOLAR	$		$		$
H. GEOTH	$		$		$
I. BIOMA	$		$		$
J. REFUS	$		$		$
K. WIND	$		$		$
L. OTHER	$		$		$
M. DEMAND SAVINGS			$ 47,964	13.59	$ 651,831
N. TOTAL			$ 47,964		$ 651,831

3. NON ENERGY SAVINGS (+) OR COST (-):

A. ANNUAL RECURRING (+/-) $
(1) DISCOUNT FACTOR (TABLE A)
(2) DISCOUNTED SAVINGS/COST (3A X 3A1) $

B. NON RECURRING SAVINGS (+) OR COST (-)

ITEM	SAVINGS(+) COST(-)(1)	YEAR OF OCCUR. (2)	DISCOUNT FACTOR(3)	DISCOUNTED SAVINGS(+)COST(-)(4)
a.	$			$
b.	$			$
c.	$			$
d. TOTAL	$			$

C. TOTAL NON ENERGY DISCOUNTED SAVINGS (3A2+3Bd4) $

4. SIMPLE PAYBACK 1G/(2N3+3A+(3Bd1/ECONOMIC LIFE)): 7.06 YEARS
5. TOTAL NET DISCOUNTED SAVINGS (2N5+3C): $ 651,831
6. SAVINGS TO INVESTMENT RATIO (SIR) 5/1G: 1.92
7. ADJUSTED INTERNAL RATE OF RETURN (AIRR): 7.45 %

1. COMPONENT	FY 19 93 MILITARY CONSTRUCTION PROJECT DATA	2. DATE
ARMY		25 March 93

3. INSTALLATION AND LOCATION	4. PROJECT TITLE
Lyster Army Community Hospital Fort Rucker, Alabama	ECIP

5. PROGRAM ELEMENT	6. CATEGORY CODE	7. PROJECT NUMBER	8. PROJECT COST ($000)
	80000		339

9. COST ESTIMATES

ITEM	U/M	QUANTITY	UNIT COST	COST ($000)
420,000 Gallon Steel, Thermal Storage Tank	EA	1	160,000	160
Insulation	LS	--	--	37
Diffuser	EA	1	21,000	21
Site Preparation And Foundations	LS	--	--	30
Upgrade Chiller Pumping System	LS	--	--	7
400' - 6" Diameter Steel Piping With Fittings	LF	400	34.02	14
Control Valve For Building Automation System	EA	1	4,500	5
30 Control Points For Building Automation Sys.	EA	30	750	22
Miscellaneous Mechanical And Electrical	LS	--	--	8
Supervision, Inspection & Overhead (5.5%)				17
Design (6.0%)				18
TOTAL				339

10. DESCRIPTION OF PROPOSED CONSTRUCTION

The primary facility of the cooling storage system will include a steel storage tank, insulation, diffuser, site preparation and foundations, upgrading of chiller pumping system, steel piping with fittings and control valve and points to interface with the Building Automation System. The work is new construction at Lyster Army Community Hospital. The purpose of this facility is to reduce peak electrical demand at the hospital by use of a cooling storage system utilizing the existing chillers. Demolition of existing buildings is not required for site clearance. Accessibility for the handicapped is not required for functional reasons.

11. Project:

Install a cooling storage system for peak demand reduction. This project will save $47,964 per year in electrical demand charges.

DD FORM 1391, 1 DEC 76 — PREVIOUS EDITIONS MAY BE USED INTERNALLY UNTIL EXHAUSTED. — PAGE NO.

FOR OFFICIAL USE ONLY

(WHEN DATA IS ENTERED)

1. COMPONENT		2. DATE
ARMY	FY 19 93 MILITARY CONSTRUCTION PROJECT DATA	25 March 93

3. INSTALLATION AND LOCATION	
Lyster Army Community Hospital Fort Rucker, Alabama	
4. PROJECT TITLE	**5. PROJECT NUMBER**
ECIP	

REQUIREMENT:

This project is required to provide a reduction of overall electrical cost by reducing the monthly demand charge for electricity by utilizing a chilled water storage system. The project has a Savings To Investment Ratio (SIR) of 1.92. The ECIP Life Cycle Cost Analysis summary sheet is attached.

CURRENT SITUATION:

Ft. Rucker is billed for electrical demand charges each month by establishing the highest fifteen minute period usage for the entire year. This on-peak demand sets the basis for demand charges for the following eleven months subject to a 75% ratchet clause. A chilled water cooling storage system at Lyster Army Community Hospital would reduce this peak demand at the base meter by shifting the electrical demand of the chillers to off-peak periods. The chillers would produce chilled water during off-peak periods and this water would be stored for use during on-peak periods.

IMPACT:

Ft. Rucker will continue to operate the chillers at Lyster Army Community Hospital during the on-peak hours when the basis for electrical demand charges are set and lose a potential annual savings of $47,964 in electrical demand costs.

SECTION 4.0 APPENDIX

COOLING STORAGE SYSTEM FOR PEAK DEMAND REDUCTION

LYSTER ARMY COMMUNITY HOSPITAL

APPENDIX 4A

ORIGINAL ECO FROM 1989 STUDY

VARIABLE PUMPING

ECO 2 Variable Pumping

Lyster Army Hospital

Existing Conditions: The central chilled water system consists of three centrifugal chillers: two 230 ton chillers and one 360 ton chiller. Each chiller is served by an individual cooling tower. The two 230 ton chillers are served by a 50 hp chilled water pump (P-1) and an equal stand-by pump (P-2). At the time of the field survey for this study, the piping arrangement was configured so that the pump in use must pump through both chillers anytime that either chiller is operating. This configuration has since been modified. Valves have now been installed to eliminate the need to pump water through both chillers. No modifications to pumping velocity was addressed when valves were installed. Excess velocity could damage tubes. Tube wear should be closely monitored.

The chillers are manually staged by operating personnel to meet the building load. Refer to the existing chilled water system schematic. Pumps now run at full speed and flow. Both three-way and two-way valves are in use at the air handling units. The hospital has a year-round, 24 hour per day cooling load.

Recommended Modification: The chilled water system should be converted into a primary/secondary loop system with variable water flow in the secondary loop. Automatic chiller staging would be accomplished via a flow measuring device (turbine meter or an oriface) in the bypass leg of the primary loop. According to the TRACE load profile, one 230 ton chiller and the 360 ton chiller would meet the anticipated load. The other 230 ton chiller would remain as a stand-by and would be available on the rare occasions that the building load tops 590 tons (Note: This "stand-by" chiller would operate in the same fashion as the other chillers should its use be necessary). Three new constant flow primary pumps should be installed; a 15 HP pump for the 360 ton service (P-6) and 2 - 7.5 HP pumps for the 230 ton chillers (P-4 & P-5). Each chiller should be controlled by leaving supply water temperature, and its associated primary loop pump should operate coincident with the chiller. Each chiller should be isolated from the others by an automatic isolation valve in the primary loop. Existing piping will require revision in order to institute a primary/secondary loop system.

Existing pump P-3, a 40 HP pump which currently serves the 360 ton chiller, should be relocated into a secondary loop position. The pump impeller should be trimmed for the secondary loop head. Pumps P-1 and P-2 should have an impeller change-out and should be revised to 1150 rpm constant speed operation with new 1150 rpm motors for secondary loop service. These pumps are only 5 years old and can be effectively modified for secondary loop service. A variable frequency drive should be installed to provide variable flow from pump P-3.

The variable frequency drive should be controlled by a differential pressure sensor which will sense the pressure between the supply and return chilled water lines at the AHU furthermost from the chillers (at the end of the "longest run"). The pressure sensor should use a proportional/integral controller to maintain setpoint. The differential pressure sensor will be initially set to maintain pressure required for design water flow for the air handling unit (AHU) at the end of the "longest run". This setting is usually between 10 to 30 feet head. This design setting is the starting point for balancing the water flow. Trial and error adjustments will be necessary to properly balance water flow.

The chilled water flow modulation should be as follows. Pump P-3 will modulate chilled water flow in the secondary loop up through its full speed operation at an approximate load of 360 tons. If additional chilled water is required, control logic would bring on one of the constant speed secondary pumps. Pump P-3 would then modulate its flow in combination with the constant flow of P-1 (or P-2) to meet the load. A primary loop bypass should be maintained. All existing three-way valves should be revised to two-way operation by blocking the valve bypass port. Some large 3 way valves can require different springs or pilot positions to operate as a 2 way valve. The only 3 way valves where this might be necessary, AC-2 and AC-3, are to be replaced under a different project (new controls for these two AHUs). Refer to the recommended chilled water system schematic.

Calculations use one of the two 230 ton chillers as the base load chiller, supplemented by the 360 ton chiller. This operational schematic is necessary for ECO 11 - Automatic Tube Cleaners and ECO 12 - Auxiliary Condenser to be cost effective. Operation of chillers in the primary loop is independent of secondary loop pump operation. The secondary loop pumps will vary according to building load, as will the chillers. No problems will occur by using a pump with flow capacity of 360 tons in conjunction with a 230 ton base load chiller. This configuration also maximizes energy savings.

Economic Summary:

Implementation Cost $69,300

Energy Savings

Electric	1,879.9 MBTU/YR	$24,232
Nat Gas	0 MBTU/YR	$ 0
Total	1,879.9 MTBU/YR	$24,232

Simple Payback 2.9 years

SIR 2.99

LIFE CYCLE COST ANALYSIS SUMMARY
ENERGY CONSERVATION INVESTMENT PROGRAM (ECIP)

LOCATION: FORT RUCKER REGION NO.: 4 PROJECT NUMBER: S-458
PROJECT TITLE: VARIABLE PUMPING FISCAL YEAR: 1990
DISCRETE PORTION NAME: TITLE C:\CMW\RECO2.LCC
ANALYSIS DATE: 11-14-88 ECONOMIC LIFE: 15 PREPARED BY: AMA

1. INVESTMENT

A. CONSTRUCTION COST	$69,058.00	
B. SIOH (1A * 5.5%)	$3,798.19	
C. DESIGN COST(1A * 6%)	$4,143.48	
D. ENERGY CREDIT CALC (1A+1B+1C) * 90%	$69,299.70	
E. SALVAGE VALUE	$0.00	
F. TOTAL INVESTMENT (1D-1E)		$69,299.70

2. ENERGY SAVINGS (+) / COST (-)
BASE YEAR ANNUAL SAVINGS, UNIT COST & DISCOUNTED SAVINGS

FUEL	UNIT COST $/MBTU(1)	SAVINGS MBTU/YR(2)	ANNUAL $ SAVINGS(3)	DISCOUNT FACTOR(4)	DISCOUNTED SAVINGS(5)
A. ELEC	$12.89	1,879.91	$24,232.04	8.54	$206,941.60
B. DIST	$0.00	0.00	$0.00	11.29	$0.00
C. RESI	$0.00	0.00	$0.00	11.53	$0.00
D. NG.	$4.11	0.00	$0.00	13.09	$0.00
E. COAL	$0.00	0.00	$0.00	10.18	$0.00
F. TOTAL		1,879.91	$24,232.04		$206,941.60

3. NON ENERGY SAVINGS (+) / COST (-)

A. ANNUAL RECURRING (+/-)		$0.00	
(1). DISCOUNT FACTOR (TABLE A)	9.10		
(2). DISTILLATE HANDLING COST (.0603*2B)		$0.00	
(3). DISCOUNTED SAVINGS/COST ((3A*3A2)*3A1)		$0.00	
B. NON RECURRING SAVINGS/COST NONE			
C. TOTAL NON ENERGY DISCOUNTED SAVINGS (+) COST (-) (3A3+3B)			$0.00

D. NON ENERGY DISCOUNTED SAVINGS IS = OR < 25% OF TOTAL

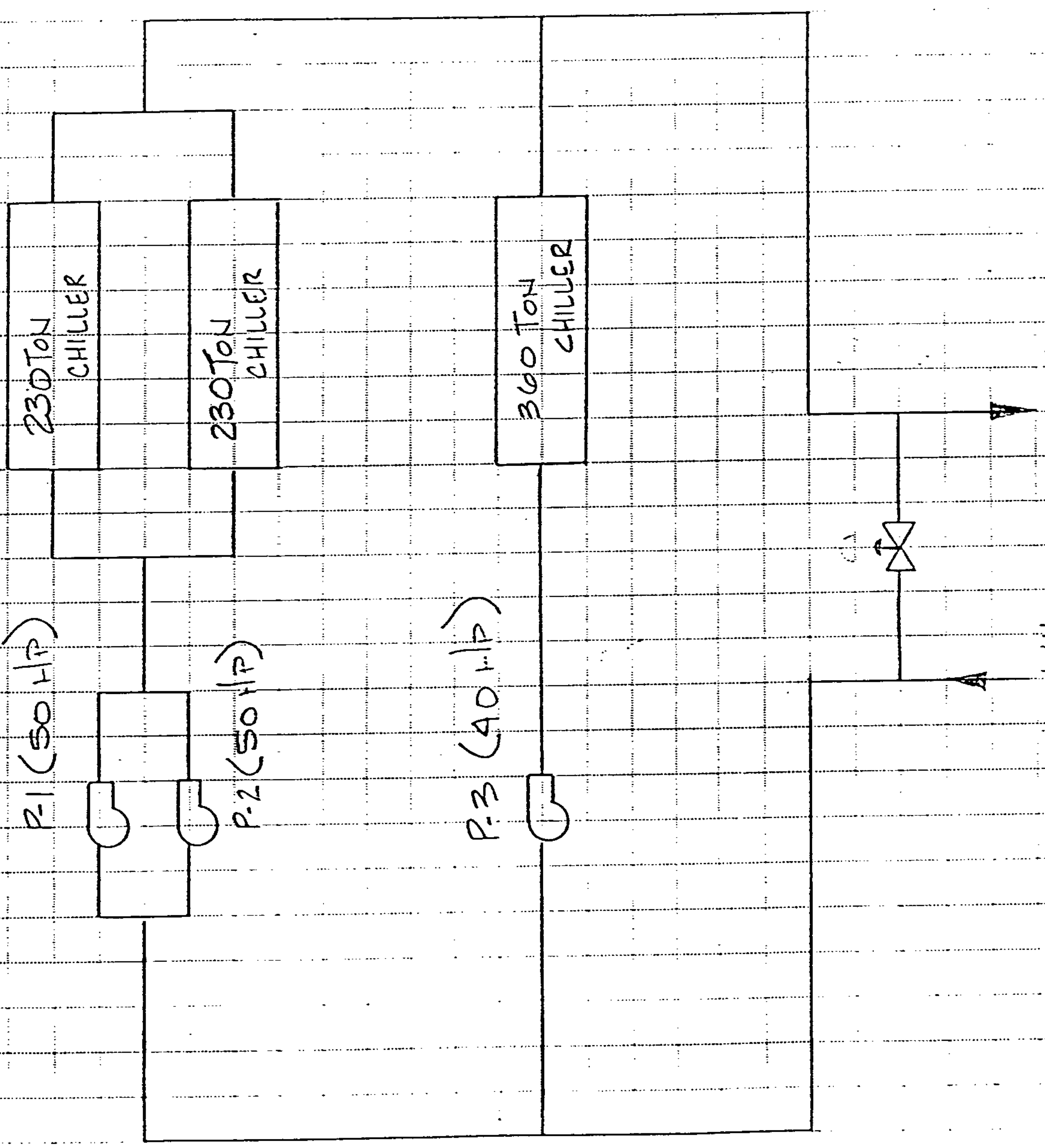
4. FIRST YEAR DOLLAR SAVINGS (2F3+3A+(3B/ECONOMIC LIFE)) $24,232.04

5. TOTAL NET DISCOUNTED DOLLAR SAVINGS (2F5+3C) $206,941.60

6. DISCOUNT SAVINGS RATIO (IF < 1 PROJECT DOES NOT QUALIFY) (SIR) = (5/1F) 2.99

ENERGY MANAGEMENT CONSULTANTS, INC.
P.O. Box 360687
BIRMINGHAM, AL 35236
(205) 985-9090

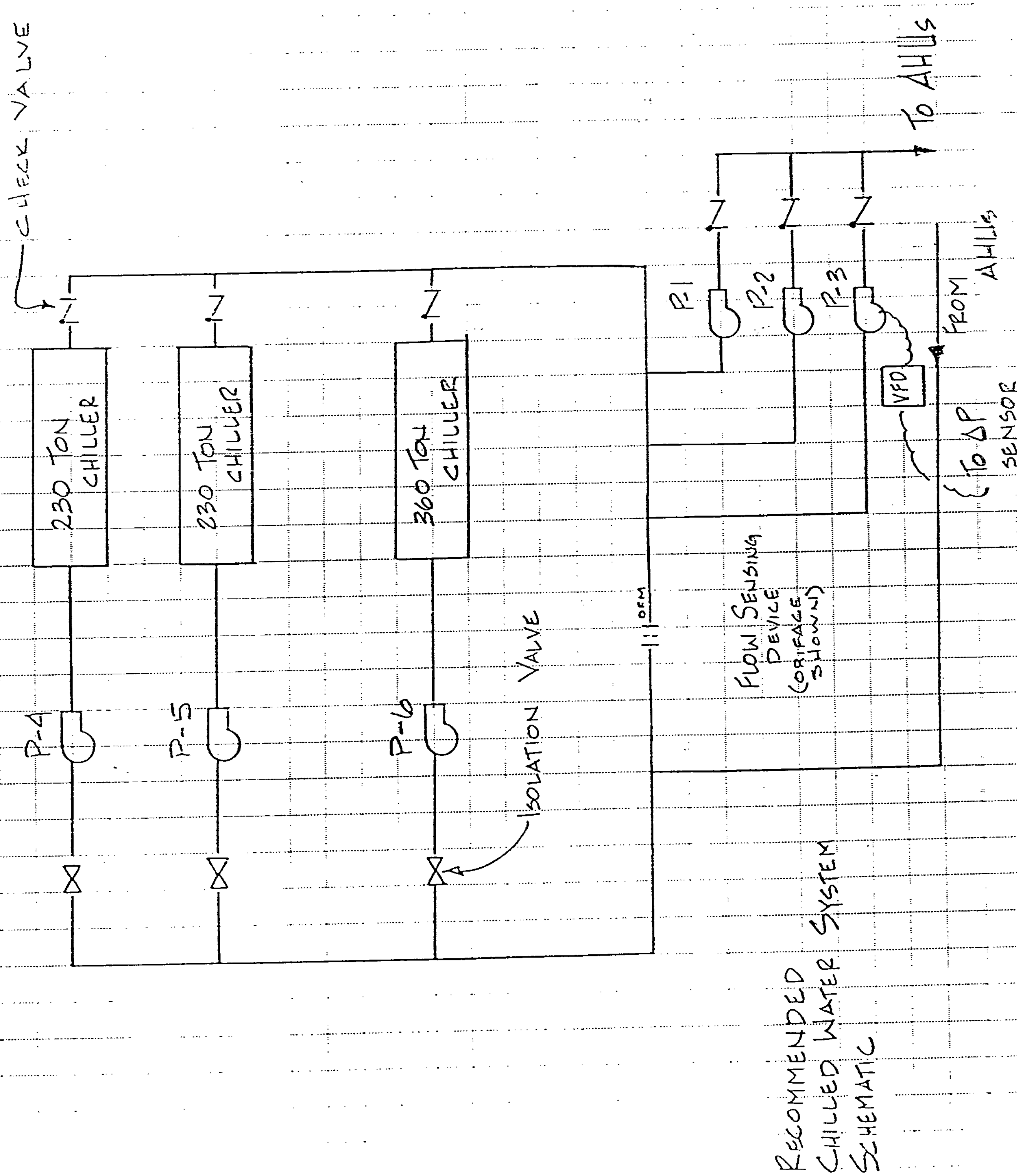
JOB ____
SHEET NO ____ OF ____
CALCULATED BY ____ DATE ____
CHECKED BY ____ DATE ____
SCALE ____



EXISTING CHILLED WATER SYSTEM SCHEMATIC

ENERGY MANAGEMENT CONSULTANTS, INC.
P.O. Box 360687
BIRMINGHAM, AL 35236
(205) 985-9090

JOB ______
SHEET NO ______ OF ______
CALCULATED BY ______ DATE ______
CHECKED BY ______ DATE ______
SCALE ______



ENERGY
MANAGEMENT CONSULTANTS, INC.
P.O. Box 360687
BIRMINGHAM, AL 35236
(205) 985-9090

JOB [illegible]
SHEET NO OF
CALCULATED BY [illegible] DATE [illegible]
CHECKED BY DATE
SCALE

ECO 2 VARIABLE [illegible]

PURPOSE: TO CALCULATE THE ENERGY SAVINGS FROM IMPLEMENTING VARIABLE FLOW PUMPING IN A SECONDARY CHILLED WATER LOOP. THE TWO PUMPS SERVING THE 230 CHILLERS WILL REVISED TO 1150 RPM FOR SECONDARY LOOP SERVICE. THE IMPELLER WILL BE TRIMMED ON THE 360 TON CHILLED WATER PUMP, AND THE PUMP WILL BE USED IN THE SECONDARY LOOP. THREE NEW PRIMARY PUMPS WILL BE ADDED.

APPROACH: THE EXISTING PUMPING ENERGY IS BASED UPON MANUAL STAGING OF THE EXISTING PUMPS.
NEW CHILLED WATER PUMPING ENERGY WILL BE BASED UPON CONSTANT FLOW PRIMARY PUMPS AND VARIABLE FLOW SECONDARY PUMPS.

EXISTING PUMPING ENERGY IS TAKEN FROM THE TRACE EMCS RUN.

NEW VARIABLE PUMPING ENERGY WILL CALCULATED IN THE FOLLOWING STEPS.

1. CALCULATE PRIMARY AND SECONDARY LOOP HEADS
2. CALCULATE NEW PRIMARY PUMP HP
3. CALCULATE PRIMARY PUMPING ENERGY
4. CALCULATE NEW SECONDARY PUMP HP
5. CALCULATE NEW SECONDARY PUMPING ENERGY BASED UPON VARIABLE FREQUENCY DRIVE TYPICAL LOADING CURVE AND EMCS LOADING CURVE FOR COOLING

CALCULATE SAVINGS

ENERGY
MANAGEMENT CONSULTANTS, INC.
P.O. Box 360687
BIRMINGHAM, AL 35236
(205) 985-9090

JOB LYSTER ARMY HOSPITAL 1880SC
SHEET NO ______ OF ______
CALCULATED BY TDS DATE 7/7/83
CHECKED BY ______ DATE ______
SCALE ______

CALCULATIONS:

NEW PRIMARY AND SECONDARY PUMP HEADS.

PRIMARY LOOP HEAD

EVAPORATOR WATER PRESS. DROP (FROM CHILLER #3 SCHEDULE)	20.7'
PIPING AND PIPING ACCESSORIES	10
	30.7'

ASSUME → 32' OF PRIMARY HEAD

SECONDARY LOOP HEAD

FROM PUMP TEST REPORT, PUMP P-3 HAD DIFFERENTIAL HEAD OF 118'

ASSUME: SEC. LOOP HEAD = 118' - 32' = 86'

NEW PRIMARY PUMP HP

$$BHP = \frac{GPM \times HD}{3970 \times \eta_{pump}}$$

$$KW = BHP \times \frac{0.746\,KW}{HP} \times \frac{1}{\eta_{MOTOR}}$$

ASSUME: $\eta_{pump} = 0.70$ $\eta_{MOTOR} = 0.85$

$$GPM = \frac{TONS \times 24\ GPM\,°F/TON}{10°\Delta T}$$

ENERGY
MANAGEMENT CONSULTANTS, INC.
P.O. Box 360687
BIRMINGHAM, AL 35236
(205) 985-9090

JOB ____
SHEET NO ____ OF ____
CALCULATED BY ____ DATE ____
CHECKED BY ____ DATE ____
SCALE ____

CALCULATIONS

NEW PRIMARY PUMP HP CON'T.

360 TON CHILLER:

$$GPM = \frac{360\ TONS \times 24\ GPM\ °F/TON}{10°\ \Delta T}$$

$$= 864\ GPM$$

$$BHP = \frac{864\ GPM \times 32'}{3970 \times 0.70}$$

$$= 9.9\ HP$$

$$KW = 9.9\ HP \times 0.746\ KW/HP \times 1/0.85$$

$$= 8.7\ KW$$

230 TON CHILLER

$$GPM = 230\ TON \times 24\ GPM°F/TON \times 1/10°\Delta T$$

$$= 552\ GPM$$

$$BHP = \frac{552\ GPM \times 32'}{3970 \times 0.70}$$

$$= 6.4\ HP$$

$$KW = 6.4\ HP \times 0.746\ KW/HP \times 1/0.85$$

$$= 5.6\ KW$$

ENERGY MANAGEMENT CONSULTANTS, INC.
P.O. Box 360687
BIRMINGHAM, AL 35236
(205) 985-9090

JOB
SHEET NO OF
CALCULATED BY DATE
CHECKED BY DATE
SCALE

NEW PRIMARY PUMPING ENERGY

IN ACCORDANCE WITH ECO 11 & ECO 12, THE 230 TON CHILLER ADDRESSED BY THESE ECO'S MUST BE PRIMARY.

FROM THE EMCS SYSTEM COOLING LOAD PROFILE, THE 250 TON WILL OPERATE ALONE FOR 6745 HOURS/YR (5-35% LOAD). SUPPLEMENT CAN EITHER BE DONE WITH THE OTHER 230 TON MACHINE OR THE 360 TON MACHINE. FOR MAXIMUM ENERGY CONSUMPTION, RESULTING IN CONSERVATIVE SAVINGS CALCULATIONS, THE 360 TON MACHINE WILL BE USED ALONG WITH THE 250 TON MACHINE FOR 1961 HOURS/YR

$$E_{PRIM.} \quad (5.6\ KW)(6745\ HRS/YR) + (5.6 + 8.7)\ KW\ (1961\ HRS/YR)$$

$$E_{PRIM} = 65{,}814\ KWH/YR$$

NEW SECONDARY PUMP HP

360 TON CHILLER → 864 GPM

FROM THE EXISTING PUMP CURVE, THE MINIMUM IMPELLER SIZE IS 11". HEAD FOR 864 GPM IS 112' AT AN EFFICIENCY OF 75% (SEE ATTACHED PUMP CURVE). HP FROM CURVE IS 35 HP. $\eta_{MOTOR} = 85\%$

$$KW = 35\ HP \times 0.746\ KW/HP \times 1/0.85 = 30.7\ KW$$

ENERGY
MANAGEMENT CONSULTANTS, INC.
P.O. Box 360687
BIRMINGHAM, AL 35236
(205) 985-9090

JOB LYSTER ARMY HOSPITAL

SHEET NO ___ OF ___

CALCULATED BY ___ DATE ___

CHECKED BY ___ DATE ___

SCALE ___

Calculation

NEW SECONDARY PUMP HP

230 TON CHILLER GPM = 552 HEAD = 86'

FROM NEW 550 GPM PUMP CURVE AND NEW IMPELLER FOR 86' HEAD, THE HORSEPOWER IS 17.3

$$KW = 17.3\,HP \times 0.746\,KW/HP \times 1/0.85$$

$$= 15.2\,KW$$

SECONDARY CHILLED WATER PUMP P-3 WILL OPERATE AT VARYING SPEEDS UNTIL IT IS FULLY LOADED. AT A 360 TON LOAD CHILLED WATER PUMP P-1 (OR P-2) WILL START UP AND RUN AT CONSTANT, FULL SPEED AND CHWP P-3 WILL VARY SPEED TO MEET ABOVE A 230 TON LOAD

THE REDUCED SPEED PART LOAD HORSEPOWER PERCENTAGES ARE TAKEN FROM A TYPICAL VARIABLE FREQUENCY DRIVE MANUFACTURER'S DATA. COOLING LOAD PROFILE TAKEN FROM EMCS ALTERNATIVE IN THE TRACE RUN.

CHWP KW = % BHP × 30.7 KWH

TOTAL KW = 360 TON CHWP KW (P-3) + 230 TON CHWP KW (P-1)

FROM THE FOLLOWING PAGE OF SPREADSHEET DATA

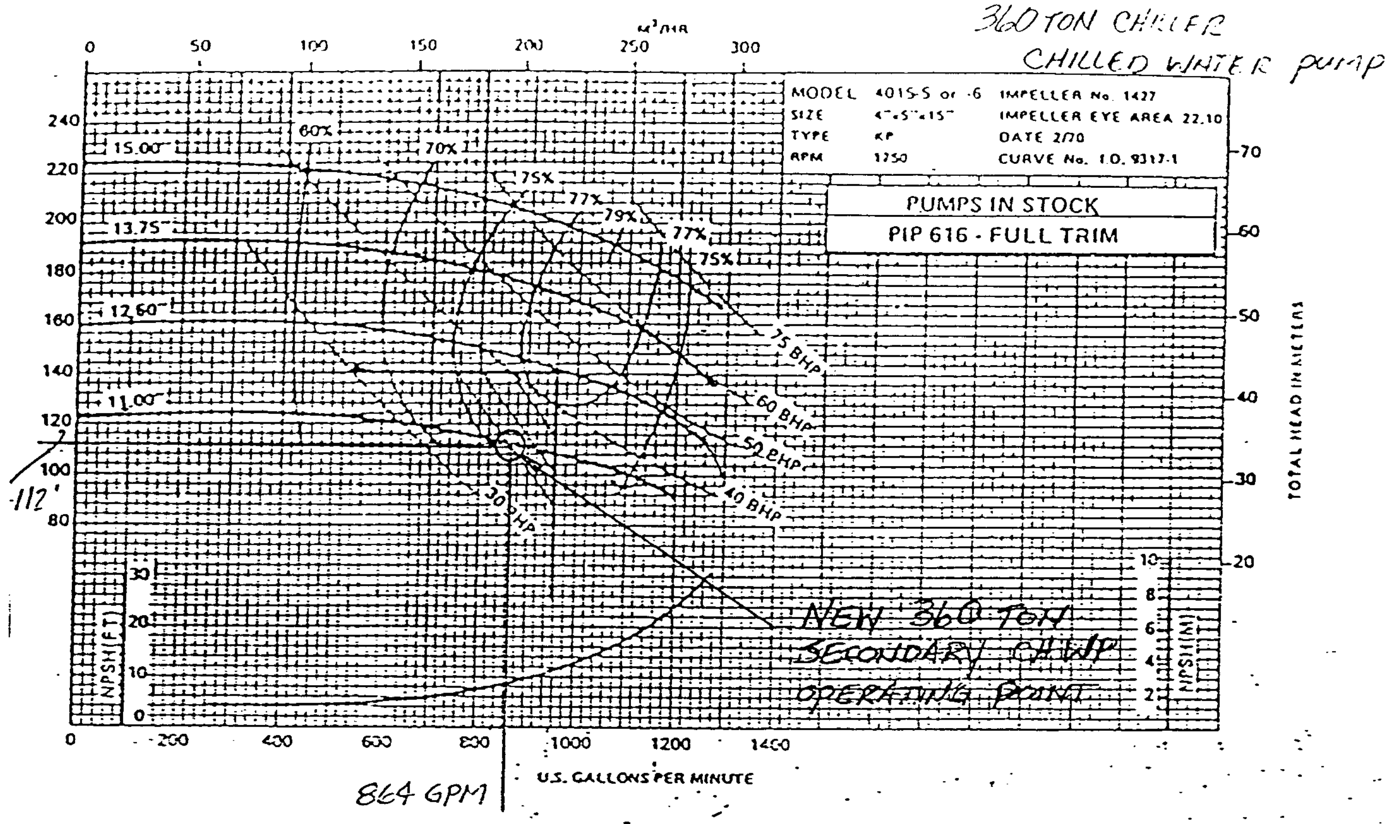
$$\boxed{E_{SEC\ CHWP} = 89{,}149\ KWH}$$

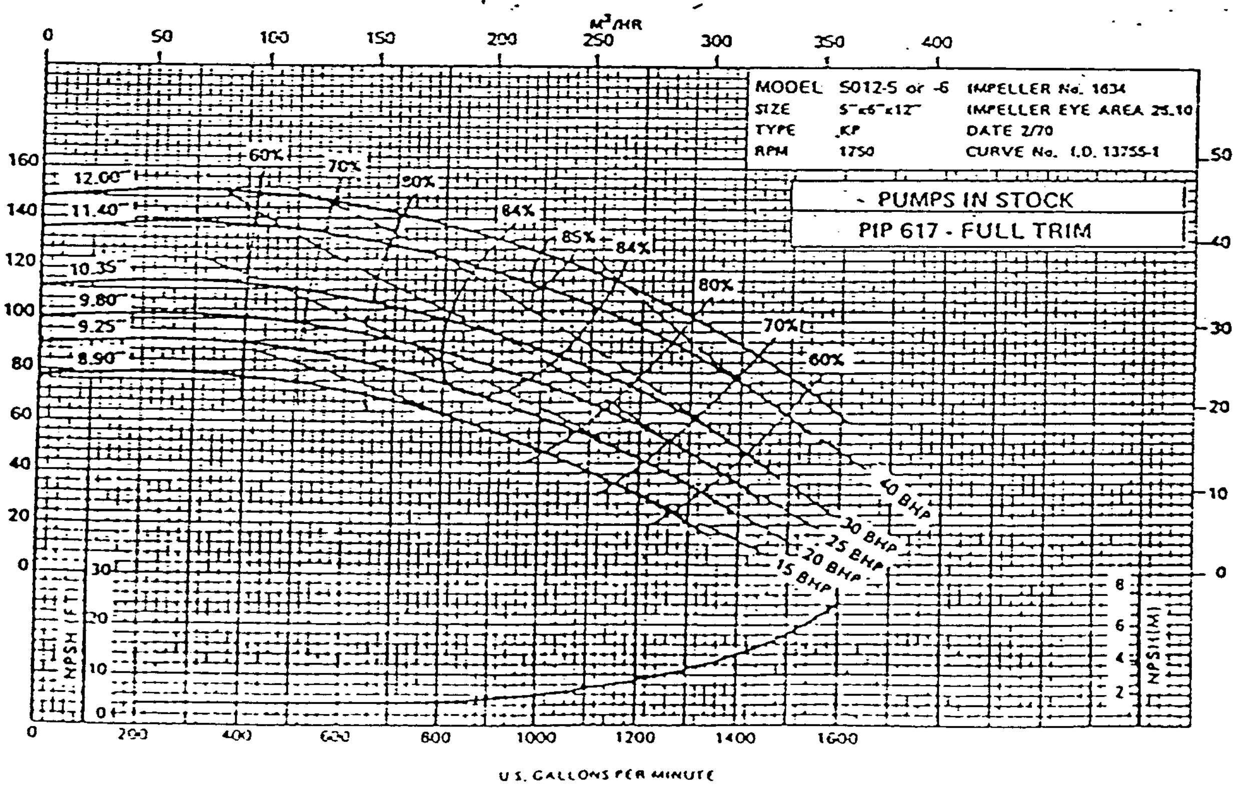
PACO PUMPS

PERFORMANCE CURVES
SPLIT CASE CENTRIFUGAL PUMPS
TYPES KP & KPV

1750 RPM

360 TON CHILLER
CHILLED WATER pump

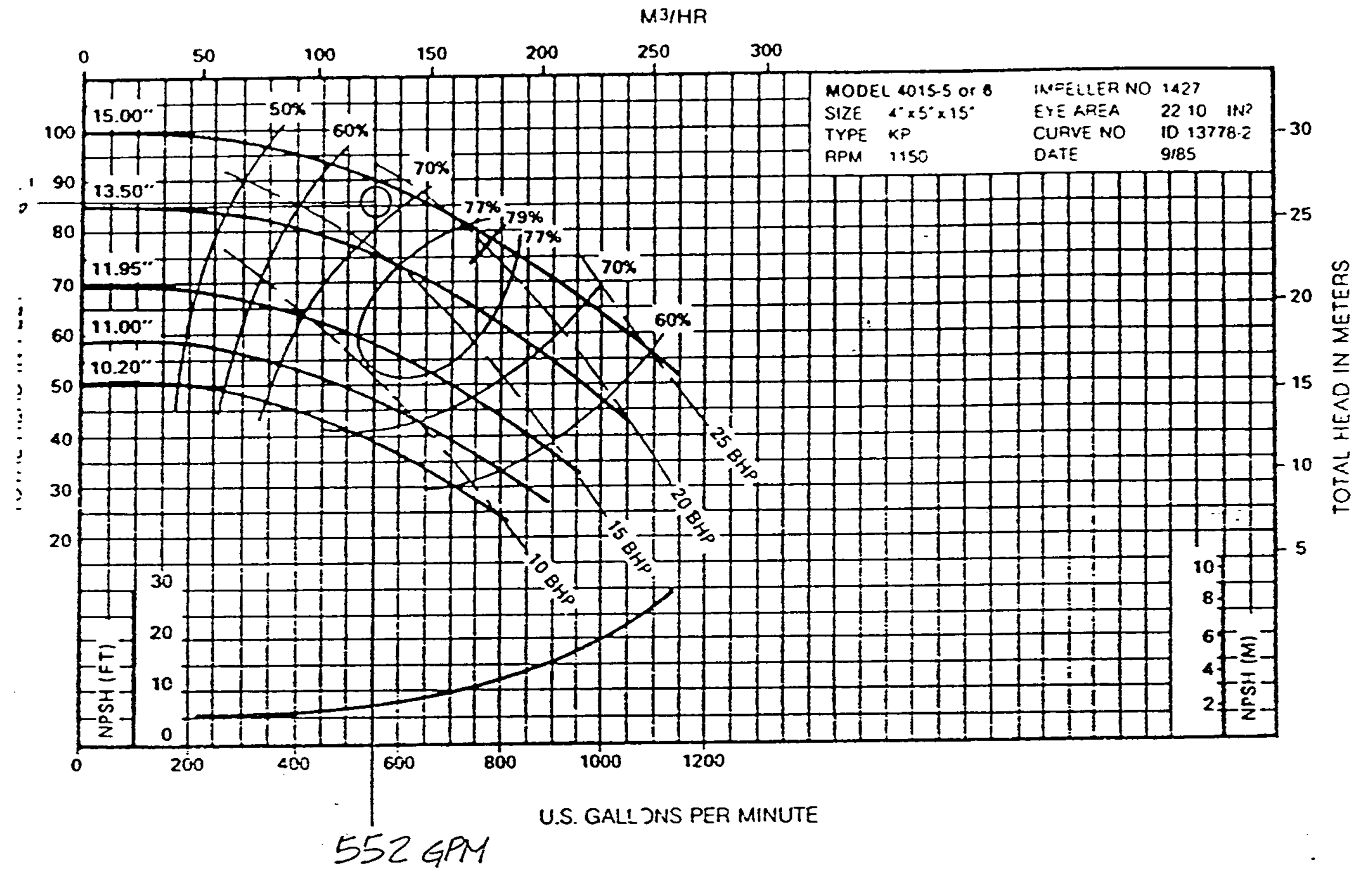


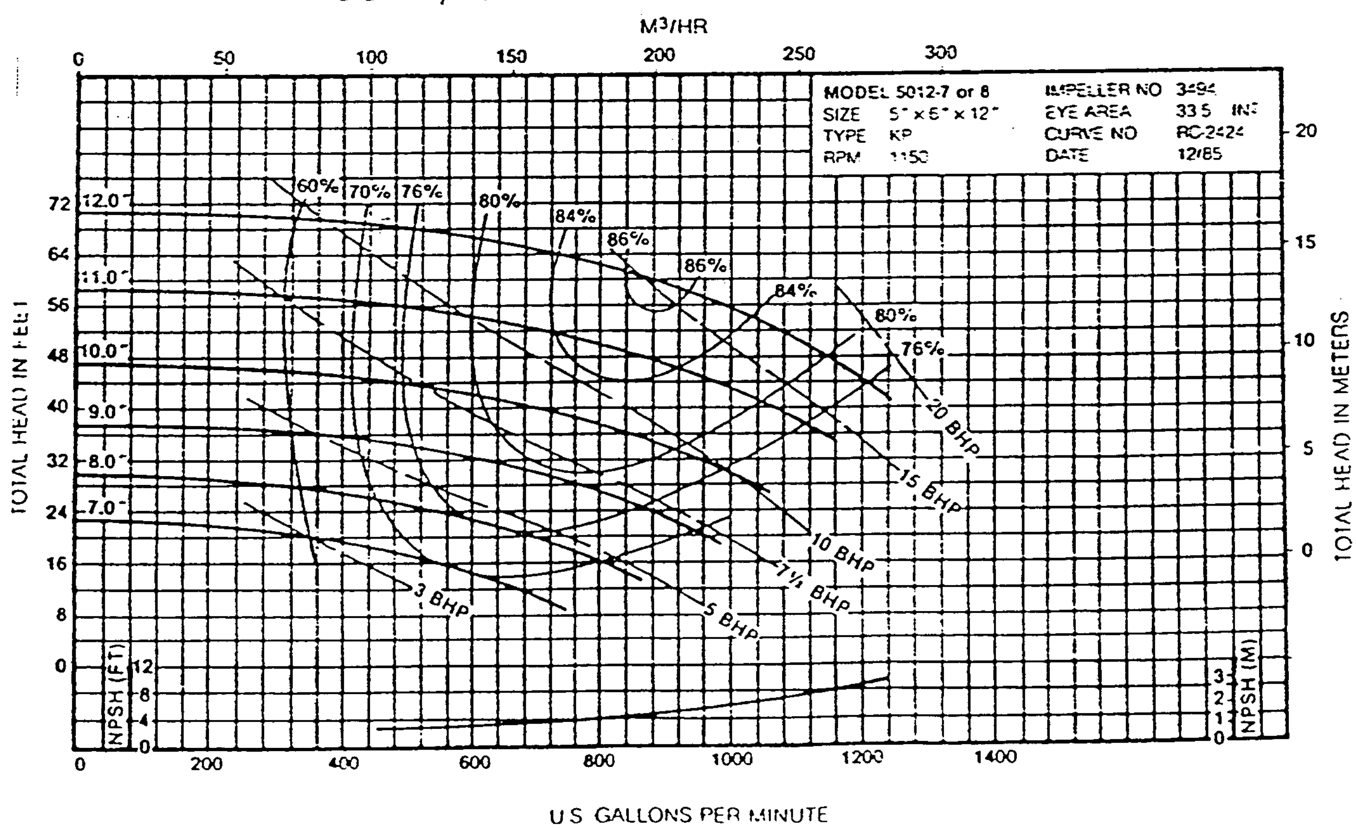


A Division of Baltimore Aircoil Company
P.O. Box 12924 • 845 92nd Avenue
Oakland, California 94604-2924

Type KP and KPV

PERFORMANCE CURVES — 1150 RPM





VARIABLE SPEED SECONDARY PUMPING ENERGY

CLG. LOAD TONS	HOURS	CHWP P-3 % LOAD	CHWP P-3 % BHP	CHWP P-3 KW	CHWP P-1 % BHP	CHWP P-1 KW	TOTAL KW	SEC. PUMP ENERGY KWH
97	5579	26.94%	21.0	6.45	0.0	0.00	6.45	35,968
130	664	36.11%	22.0	6.75	0.0	0.00	6.75	4,485
162	153	45.00%	24.0	7.37	0.0	0.00	7.37	1,127
194	187	53.89%	30.0	9.21	0.0	0.00	9.21	1,722
227	162	63.06%	38.0	11.67	0.0	0.00	11.67	1,890
259	152	71.94%	52.0	15.96	0.0	0.00	15.96	2,427
291	371	80.83%	52.0	15.96	0.0	0.00	15.96	5,923
324	309	90.00%	73.0	22.41	0.0	0.00	22.41	6,925
356	385	98.89%	92.0	28.24	0.0	0.00	28.24	10,874
389	191	44.17%	24.0	7.37	100.0	15.20	22.57	4,310
421	253	53.06%	30.0	9.21	100.0	15.20	24.41	6,176
453	300	61.94%	30.0	9.21	100.0	15.20	24.41	7,323

TOTAL 89,149

CHWP P-3 OPERATES AT VARIABLE SPEED UP TO APPROXIMATELY 360 TONS. CHWP P-1, A CONSTANT SPEED PUMP, THEN IS BROUGHT ON LINE TO SUPPLEMENT CHWP P-3.

TOTAL KW COLUMN INDICATES LOAD OF VARIABLE SPEED AND CONSTANT SPEED PUMP.

SYSTEM LOAD PROFILE ALTERNATIVE 4
EMCS SCHEDULED START STOP

PCT	TOTALS COOLING TONS	TOTALS PERCENT HRS	TOTALS HRS	TOTALS HEATING MBH	TOTALS PERCENT HRS	TOTALS HRS	TOTALS CFM	TOTALS PERCENT HRS	TOTALS HRS
5	32.39	38.90	3387	203.38	52.88	4632	8251.76	0.0	0
10	64.77	15.20	1323	406.76	14.60	1279	16503.52	0.0	0
15	97.16	9.98	869	610.15	6.74	590	24755.29	0.0	0
20	129.55	7.63	664	813.53	14.95	1310	33007.05	0.0	0
25	161.94	1.76	153	1016.91	1.89	166	41258.81	13.73	1203
30	194.32	2.15	187	1220.29	1.59	139	49510.57	36.27	3177
35	226.71	1.85	162	1423.67	1.64	144	57762.33	0.0	0
40	259.10	1.75	152	1627.05	1.64	144	66014.06	0.0	0
45	291.49	4.26	371	1830.44	1.14	100	74265.81	0.0	0
50	323.87	3.55	309	2033.82	1.13	99	82517.56	0.0	0
55	356.26	4.42	385	2237.20	0.76	67	90769.37	0.0	0
60	388.65	2.19	191	2440.58	0.49	43	99021.12	0.0	0
65	421.04	2.91	253	2643.96	0.33	29	107272.87	0.0	0
70	453.42	3.45	300	2847.34	0.14	12	115524.62	0.0	0
75	485.81	0.0	0	3050.73	0.07	6	123776.37	0.0	0
80	518.20	0.0	0	3254.11	0.0	0	132028.19	0.0	0
85	550.59	0.0	0	3457.49	0.0	0	140279.94	0.0	0
90	582.97	0.0	0	3660.87	0.0	0	148531.69	0.0	0
95	615.36	0.0	0	3864.25	0.0	0	156783.44	0.0	0
100	647.75	0.0	0	4067.63	0.0	0	165035.19	50.00	4380
HOURS OFF			54			0			0

6745

ENERGY
MANAGEMENT CONSULTANTS, INC.
P.O. Box 360687
BIRMINGHAM, AL 35236
(205) 985-9090

JOB Lyster Army Hospital
SHEET NO ____ OF ____
CALCULATED BY ____ DATE ____
CHECKED BY ____ DATE ____
SCALE ____

CALCULATION

ENERGY SAVINGS

EXISTING CHWP ENERGY (FROM TRACE OUTPUT)

$$\boxed{E_{\substack{EXST\\CHWP}} = 705,773 \text{ KWH}}$$

NEW CHWP ENERGY

$$E_{\substack{NEW\\CHWP}} = E_{\substack{PRI\\CHWP}} + E_{\substack{SEC\\CHWP}}$$

$$= (65,814 + 89,149) \text{ KWH}$$

$$= 154,963 \text{ KWH}$$

ENERGY SAVINGS

$$\Delta E_{CHWP} = E_{\substack{EXST\\CHWP}} - E_{\substack{NEW\\CHWP}}$$

$$= 705,773 - 154,963$$

$$\boxed{\Delta E_{CHWP} = 550,810 \text{ KWH}}$$

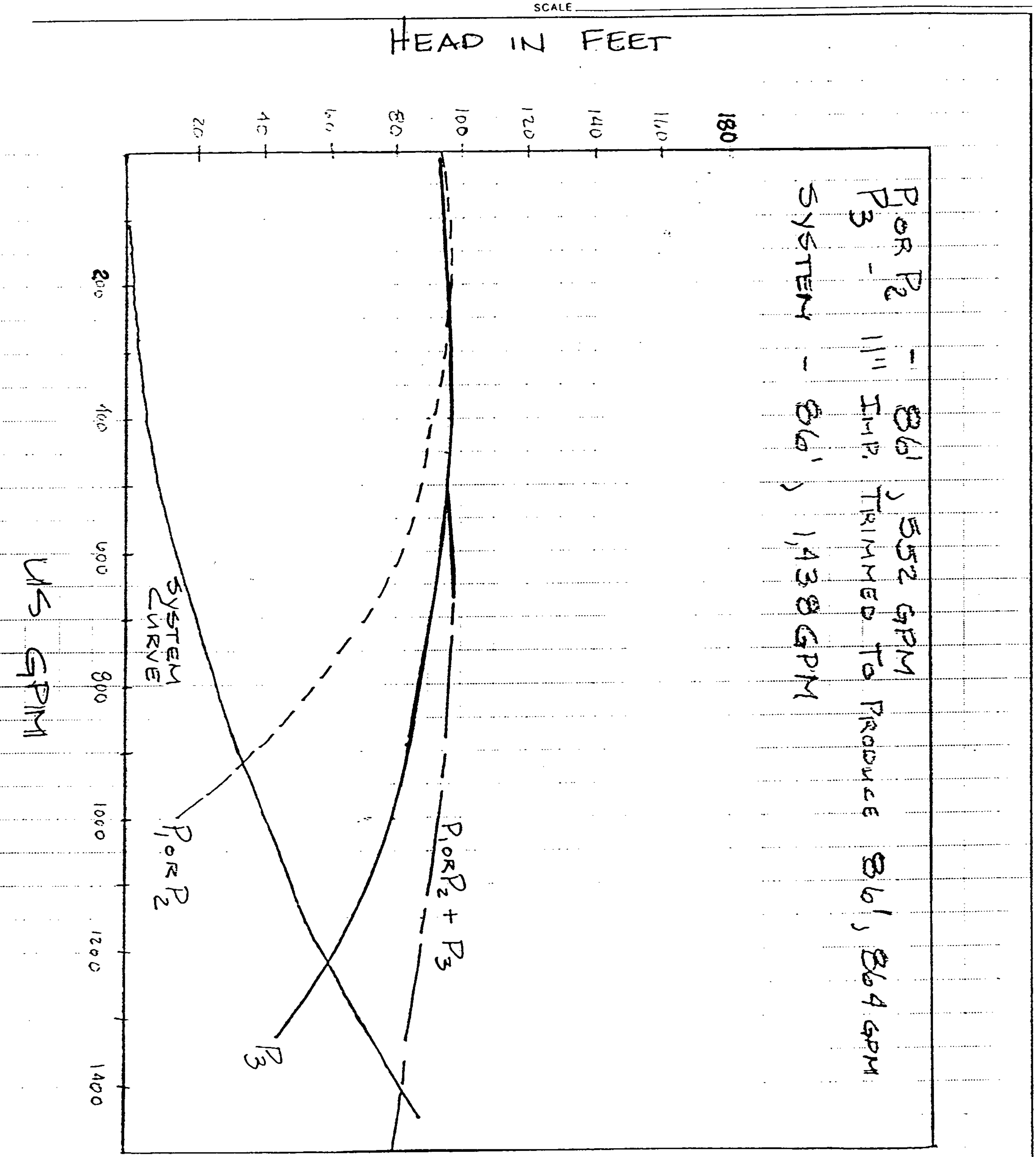
$$MBTU/YR = (550,810 \text{ KWH/YR})\left(\frac{3413}{1,000,000}\right) = 1879.91 \text{ MBTU}$$

EQUIPMENT CONSUMPTION ALTERNATIVE 2
EMCS SCHEDULED START STOP

UTILITY	JAN	FEB	MARCH	APRIL	MAY	JUNE	JULY	AUG	SEPT	OCT	NOV	DEC	TOTAL
1008 REFERENCE 1	CENTRIFUGAL CHILLER, THREE STAGE												
ELEC	7010	8447	19023	48655	75227	101461	106638	113291	98472	44295	10363	11265	644995
PEAK	22.6	25.9	90.2	180.0	217.4	262.1	256.8	266.2	250.5	157.7	46.3	50.4	
5031 REFERENCE 1	CHILLED WATER PUMP												
ELEC	58168	54291	60107	58168	60107	58168	60107	60107	58168	60107	58168	60107	705773
PEAK	80.8	80.8	80.8	80.8	80.8	80.8	80.8	80.8	80.8	80.8	80.8	80.8	
5010 REFERENCE 1	CONDENSER WATER PUMP												
ELEC	39002	36402	40302	39002	40302	39002	40302	40302	39002	40302	39002	40302	473224
PEAK	54.2	54.2	54.2	54.2	54.2	54.2	54.2	54.2	54.2	54.2	54.2	54.2	
5103 REFERENCE 1	COOLING TOWER FANS												
ELEC	84	120	10066	26431	34988	40637	42666	44637	41328	26576	215	268	268016
PEAK	0.4	0.6	64.9	64.9	64.9	64.9	64.5	64.5	64.9	64.9	2.1	2.5	
5400 REFERENCE 1	MAKE-UP WATER												
WATER	32217	34811	84119	257217	467537	611401	641805	669736	584956	249084	42704	46423	3762494
PEAK	93.2	106.8	467.3	1281.3	1507.5	1751.4	1734.0	1776.0	1692.9	1098.2	190.7	207.6	
5300 REFERENCE 1	CONTROL PANEL AND INTERLOCKS												
ELEC	2232	2016	2232	2160	2232	2160	2232	2232	2160	2232	2160	2232	26280
PEAK	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	
2004 REFERENCE 1	STEAM BOILER, 0-150 PSI GAS WATERTUBE												
GAS	12673	8540	4912	1538	690	494	345	266	316	1961	7362	6769	45969
PEAK	46.1	40.7	25.3	13.9	5.3	1.6	1.1	1.0	0.8	16.2	37.2	29.6	
5042 REFERENCE 1	CONDENSATE RETURN PUMP												
ELEC	1855	1675	1855	1795	1855	1795	1777	1855	1795	1855	1795	1855	21762
PEAK	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	
5240 REFERENCE 1	BOILER FORCED DRAFT FAN												
ELEC	3947	3565	3947	3819	3947	3819	3762	3947	3819	3947	3819	3947	46305
PEAK	5.3	5.3	5.3	5.3	5.3	5.3	5.3	5.3	5.3	5.3	5.3	5.3	
5307 REFERENCE 1	BOILER CONTROLS												
ELEC	744	672	744	720	744	720	744	744	720	744	720	744	8760
PEAK	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	
5406 REFERENCE 1	MAKE-UP WATER												
WATER	4535	3996	1781	557	250	179	129	132	114	711	2669	2454	16664
PEAK	16.7	14.8	10.6	5.1	1.9	0.6	0.4	0.4	0.3	5.9	13.5	10.7	
5020 REFERENCE 1	HEATING WATER CIRCULATION PUMP												
ELEC	5708	5155	5708	5523	5708	5523	5470	5708	5523	5708	5523	5708	66965
PEAK	7.7	7.7	7.7	7.7	7.7	7.7	7.7	7.7	7.7	7.7	7.7	7.7	

ENERGY
MANAGEMENT CONSULTANTS, INC.
P.O. Box 360687
BIRMINGHAM, AL 35236
(205) 985-9090

JOB ____
SHEET NO. ____ OF ____
CALCULATED BY ____ DATE ____
CHECKED BY ____ DATE ____
SCALE ____



ENERGY
MANAGEMENT CONSULTANTS, INC.
P.O. Box 360687
BIRMINGHAM, AL 35236
(205) 985-9090

JOB [illegible]
SHEET NO ____ OF ____
CALCULATED BY ____ DATE [illegible]
CHECKED BY ____ DATE ____
SCALE ____

VARIABLE PUMPING COST ESTIMATE

ITEM	MATERIAL	LABOR
VARIABLE FREQUENCY DRIVE (40 HP) (MANUFACTURER'S MAT. COST)	9,335	70 HRS
2 - 7.5 HP PRI[illegible] (MEANS)	4,000	40
1 - 15 HP PRIMARY PUMP (MEANS)	3,500	20
2 - 1150 RPM MOTORS (MEANS) 20 HP	1,900	30
IMPELLER TRIM (P-3) (MANU.)	1,333	25
2 - NEW IMPELLERS (P-1 & P-2) (MANU.)	3,464	50
ELIMINATE 3 WAY VALVES (CONTR.)		
PRESSURE SENSOR / PI CONTROLLER + ACCESSORIES (MANU)	1,215	60
REWORK CHILLER CONTROLS	600	30
PIPING ADDITIONS (MEANS) 100 - 10" PIPE W/ INSULATION PIPING ACCESSORIES	9,000	180
ISOLATION VALVES	900	30
ELECTRICAL INTERLOCKS	800	30
FLOW SENSOR CONTROL	1,000	20
ELECTRICAL SERVICE TO NEW EQUIPMENT	2,000	30
ADDITIONAL POINTS TO EMCS & PROGRAMMING	3,500	90
WIRING	400	60
MOTOR STARTERS	980	10
SUBTOTAL	42,879	775

COST ESTIMATE ANALYSIS

For use of this form, see TM 5-800-2; the proponent agency is USACE.

OJECT: VARIABLE PUMPING	INVITATION/CONTRACTOR	EFFECTIVE PRICING DATE	DATE PREPARED: 7/12/88
CATION: LYSTER ARMY HOSPITAL - FORT RUCKER	CODE (Check one) ☐ A ☐ B ☐ C ☐ OTHER	DRAWING NO.	SHEET 1 OF 1 SHEETS
		ESTIMATOR: TDB	CHECKED BY

TASK DESCRIPTION	QUANTITY: NO. OF UNITS	QUANTITY: UNIT MEAS	LABOR: MH UNIT	LABOR: TOTAL HRS	LABOR: UNIT PRICE	LABOR: COST	EQUIPMENT: UNIT PRICE	EQUIPMENT: COST	MATERIAL: UNIT PRICE	MATERIAL: COST	TOTAL	SHIPPING: UNIT WT	SHIPPING: TOTAL WT
ISTALLATION OF													
VARIABLE PUMPING	1	JOB		775	10.62	$8,231				$42,879	$51,110		
BOR BURDEN 18%					X.18	1,482			—		1,482		
ERHEAD 16%					X.16	1,317			X.16	6,861	8,178		
OFIT 10%					X.10	823			X.10	4,288	5,111		
ES TAX 5.5%					—	—			X.055	2,358	2,358		
						$11,853				$56,386	$68,239		
IIC 1.2%									X.012		819		
TAL											$69,058		
TOTAL THIS SHEET													

ORM 5418 R, Apr 85

APPENDIX 4B

ALABAMA POWER COMPANY

APPLICABLE ELECTRIC RATE - FT. RUCKER

BILLING HISTORY - JULY 1991 TO JUNE 1992

ALABAMA POWER COMPANY

REVISION NO. 8 - RATE SCHEDULE MR-1

1. AVAILABILITY

Available for electric service to military installations operating electric distribution systems for the resale of electric power and having service and load characteristics demonstrably similar to municipalities operating electric distribution systems for the resale of electric power.

2. CHARACTER OF SERVICE

Three-phase, 60 cycle per second service at the nominal voltage mutually agreed upon, which voltage is reasonably required to meet the immediate capacity requirements and necessary to meet the growth anticipated within the foreseeable future at the delivery point specified.

3. MONTHLY RATE

(1) Service at Distribution Voltage (Nominal Voltage of 25 kV or less):

Charge for Billing Demand:
$11.090 per kVA of billing demand

Charge for Energy:
2.15 cents per kWh

(2) Service at Subtransmission Voltage (Nominal Voltage of 46 kV):

Charge for Billing Demand:
$10.615 per kVA of billing demand

Charge for Energy:
2.15 cents per kWh

75% RATCHET

(3) Service at Transmission Voltage (Nominal Voltage of 115 kV):

Charge for Billing Demand:
$10.090 per kVA of billing demand

FT. RUCKER

Charge for Energy:
2.15 cents per kWh

INCLUDES FUEL CHARGE

The monthly rate provided herein shall apply separately for power supplied hereunder at each delivery point.

Issued by:
Travis J. Bowden
Executive Vice President

Effective: February 1, 1992

Issued on: December 3, 1991

APCO - IPS

CUSTOMER DATA SHEET

YEAR 1992

CUSTOMER NAME: US .Y AVIATION CENTER SERVICE ADDRESS: FT RUCKER

ACCOUNT NO. 663270-87580-50 BASIC METER NUMBER: 069708 SIC CODE 9710 SENT CODE 33
PERM PREM ID 800066327087580

RATE NAME	RDR	READING DATE MO	DAY	DEMAND ACTUAL	DEMAND BILLING	UNITS OF DEM	KILOWATT HOURS	FUEL ADJUSTMENT	TAX ADJUSTMENT	REVENUE ADJ EXC TAX		REV MO
-1	75	07	18	28,800	28,800	KVA	12,936,000	23,750.50-	8,534.48	529,279.18		07
.R-1		07		0	0	KVA	0	8,180.66	0.00	8,180.66	*	07
MR-1	75	08	19	28,656	28,656	KVA	14,136,000	25,953.70-	8,713.68	551,723.32		08
MR-1		08		0	0	KVA	0	8,180.66	0.00	8,180.66	*	08
MR-1	75	09	18	28,627	28,627	KVA	13,104,000	24,058.94-	8,430.75	530,878.93		09
MR-1		09		0	0	KVA	0	8,180.66	0.00	8,180.66	*	09
MR-1	75	10	18	27,936	27,936	KVA	9,816,000	30,390.34-	6,798.61	445,832.33		10
MR-1	75	11	18	21,225	21,600	KVA	8,808,000	27,269.57-	5,631.88	367,512.71		11
MR-1	75	12	18	16,704	21,600	KVA	7,896,000	24,446.02-	5,443.96	350,540.34		12
MR-1		12		0	0	KVA	0	4,103.74	0.00	4,103.74	*	12
MR-1	75	01	17	16,588	21,600	KVA	7,344,000	22,737.02-	5,198.09	340,135.47		01
MR-1		01		0	0	KVA	0	4,103.74	0.00	4,103.74	*	01
MR-1	75	02	18	16,473	21,600	KVA	7,920,000	24,520.32-	5,453.42	350,991.50		02
MR-1		02		0	0	KVA	0	4,103.74	0.00	4,103.74	*	02
MR-1	75	03	18	16,963	21,600	KVA	7,368,000	22,811.33-	5,619.24	359,163.91		03
MR-1		03		0	0	KVA	0	4,103.74	0.00	4,103.74	*	03
MR-1		03		0	0	KVA	0	0.00	0.00	9,841.23	*	03
MR-1	75	04	17	21,772	21,772	KVA	7,776,000	14,937.70-	5,054.47	376,980.25		04
MR-1		04		0	0	KVA	0	0.00	0.00	0.00	*	04
MR-1		04		0	0	KVA	0	0.00	0.00	0.00	*	04
MR-1		04		0	0	KVA	0	0.00	0.00	697.59	*	04
MR-1	75	05	18	25,776	25,776	KVA	9,672,000	18,579.91-	7,151.62	456,599.55		05
MR-1	75	06	18	26,496	26,496	KVA	11,592,000	22,268.23-	7,851.14	502,155.55		06
MR-1		06		0	0	KVA	0	10,399.84-	0.00	10,399.84-	*	06
TOTALS				276,016	296,063		118,368,000	251,166.48-	79,881.34	5,202,888.96		

APPENDIX 4C

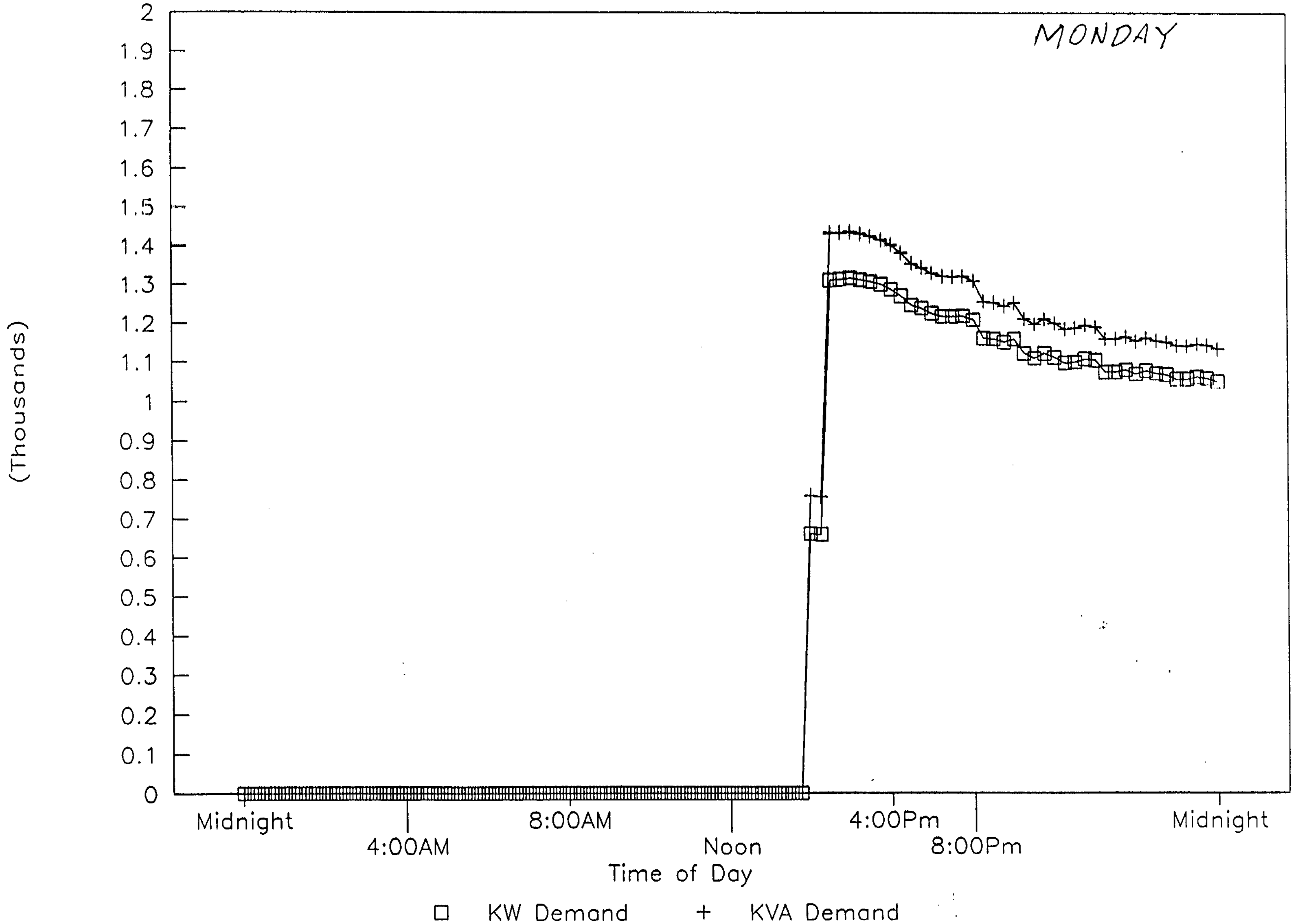
ELECTRICAL METERING PROFILES

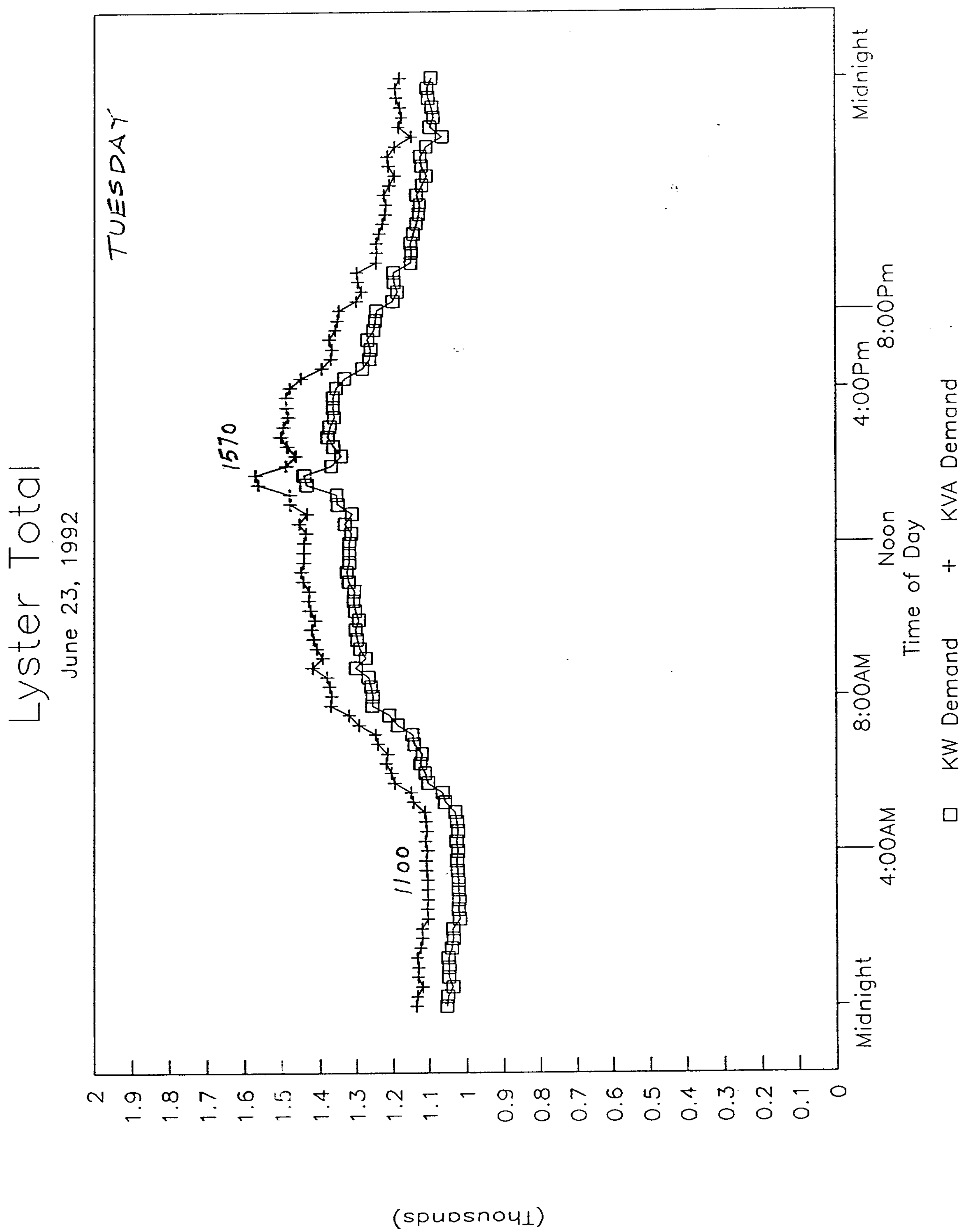
KW & KVA DEMAND

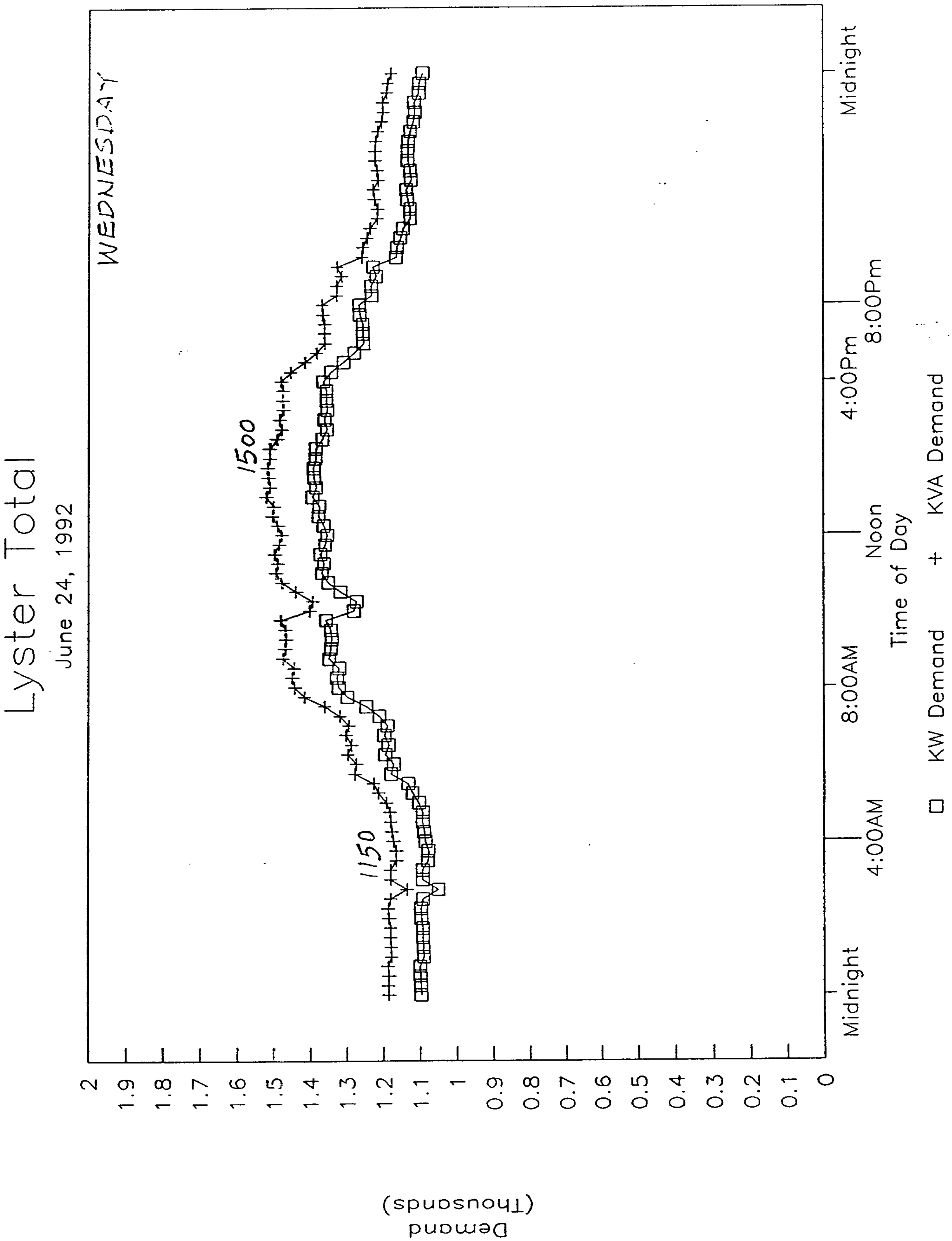
JUNE 22 TO JULY 2, 1992

Lyster Total

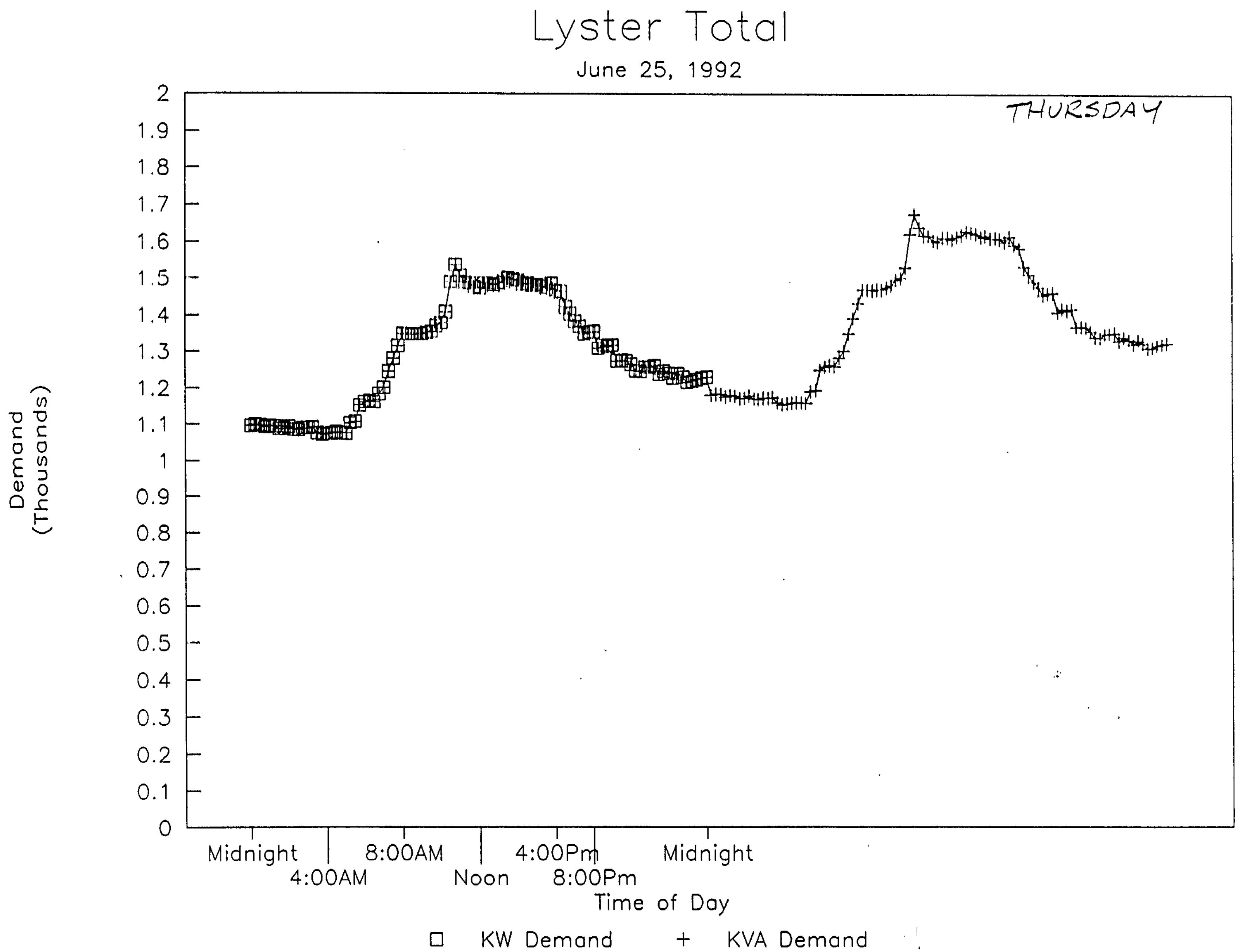
June 22, 1992



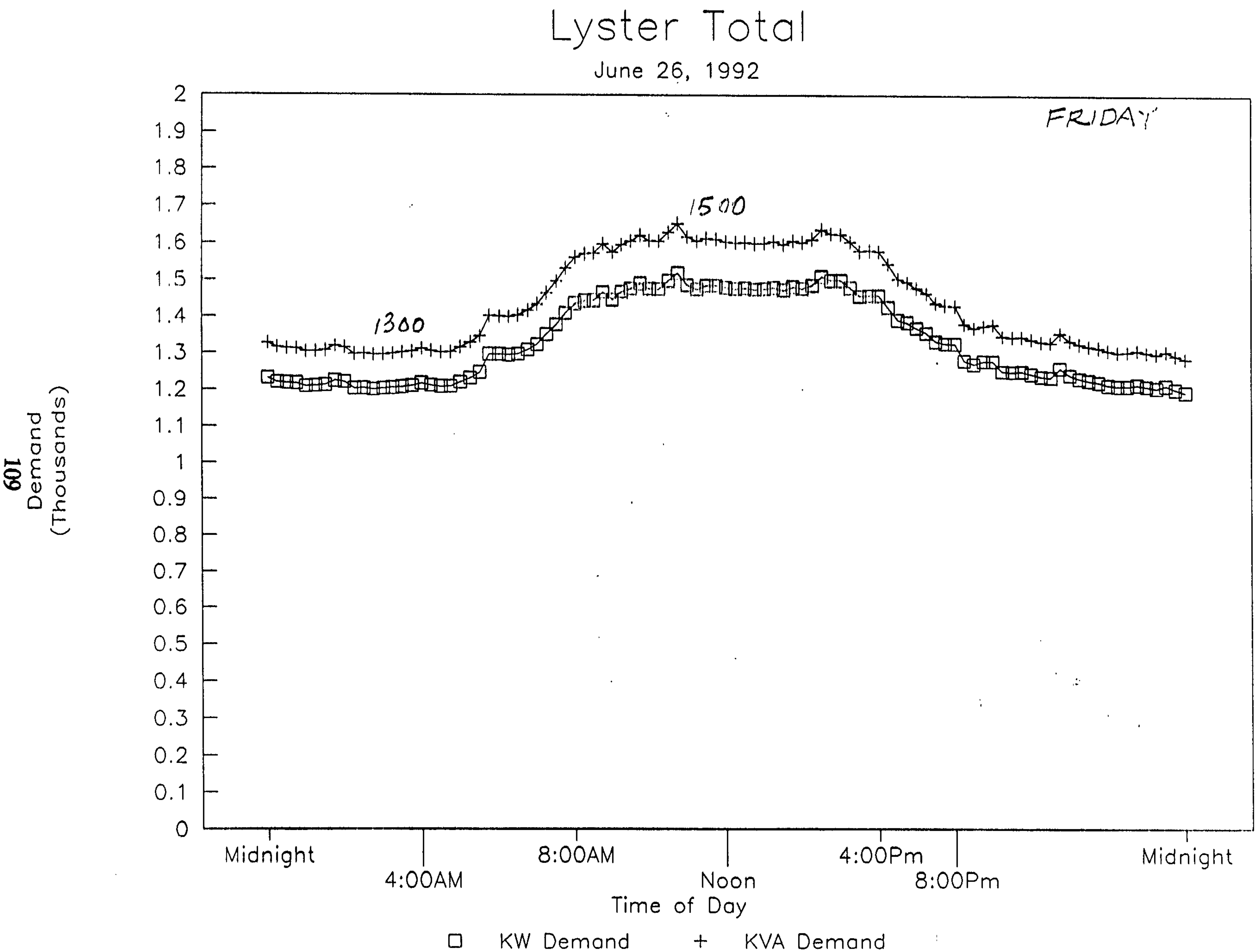

Lyster Total
June 23, 1992
TUESDAY
1570
1100
Demand
(Thousands)
2
1.9
1.8
1.7
1.6
1.5
1.4
1.3
1.2
1.1
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
Midnight
4:00AM
8:00AM
Noon
4:00Pm
8:00Pm
Midnight
Time of Day
□ KW Demand + KVA Demand



Lyster Total
June 24, 1992
WEDNESDAY
1150
1500
Demand
(Thousands)
2
1.9
1.8
1.7
1.6
1.5
1.4
1.3
1.2
1.1
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
Midnight
4:00AM
8:00AM
Noon
4:00Pm
8:00Pm
Midnight
Time of Day
KW Demand
KVA Demand



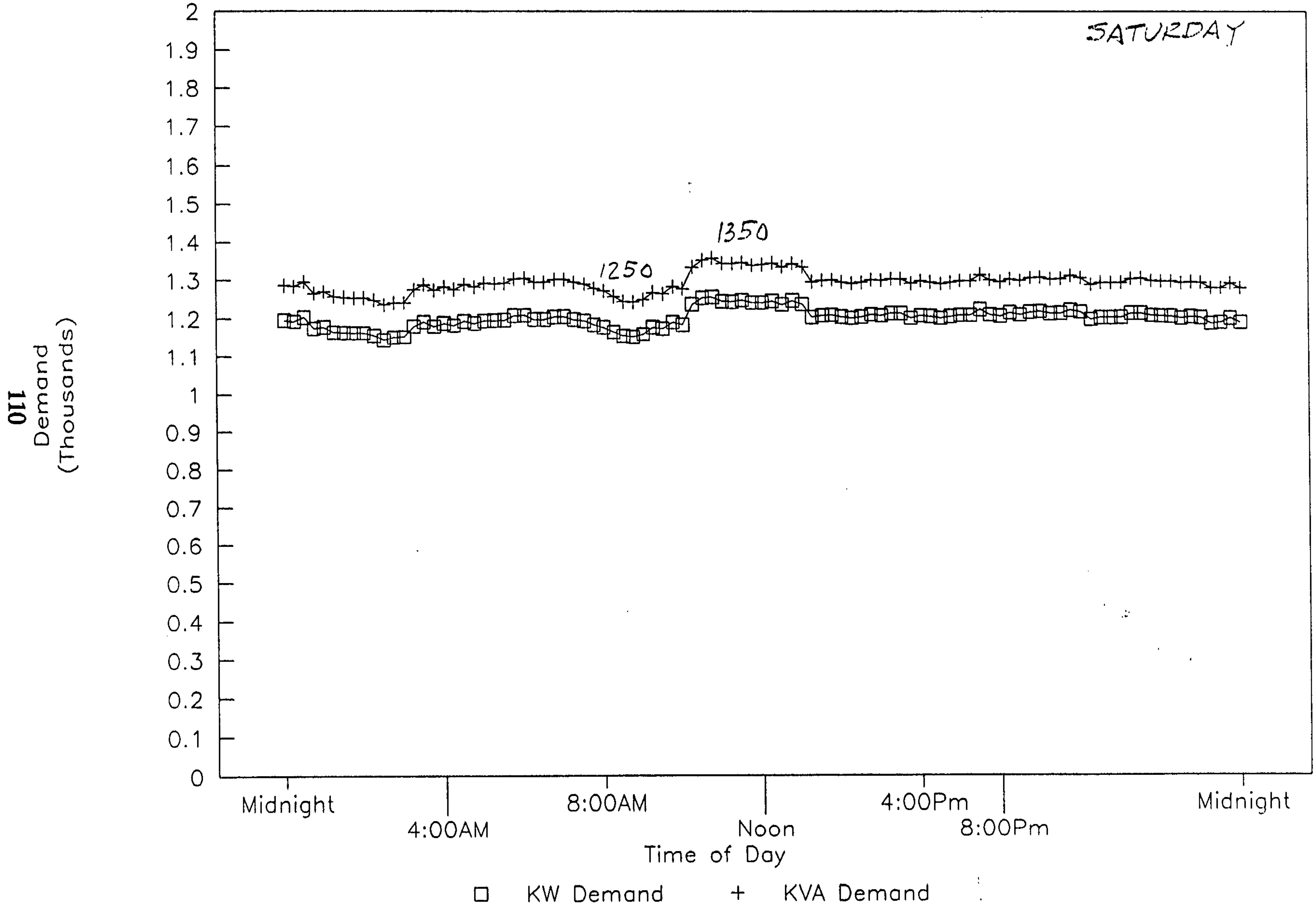
Lyster Total
June 25, 1992
THURSDAY
Demand (Thousands)
2
1.9
1.8
1.7
1.6
1.5
1.4
1.3
1.2
1.1
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
Midnight
4:00AM
8:00AM
Noon
4:00Pm
8:00Pm
Midnight
Time of Day
□ KW Demand
+ KVA Demand



Lyster Total
June 26, 1992
FRIDAY
1500
1300
Demand (Thousands)
2
1.9
1.8
1.7
1.6
1.5
1.4
1.3
1.2
1.1
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
Midnight
4:00AM
8:00AM
Noon
4:00Pm
8:00Pm
Midnight
Time of Day
KW Demand
+ KVA Demand

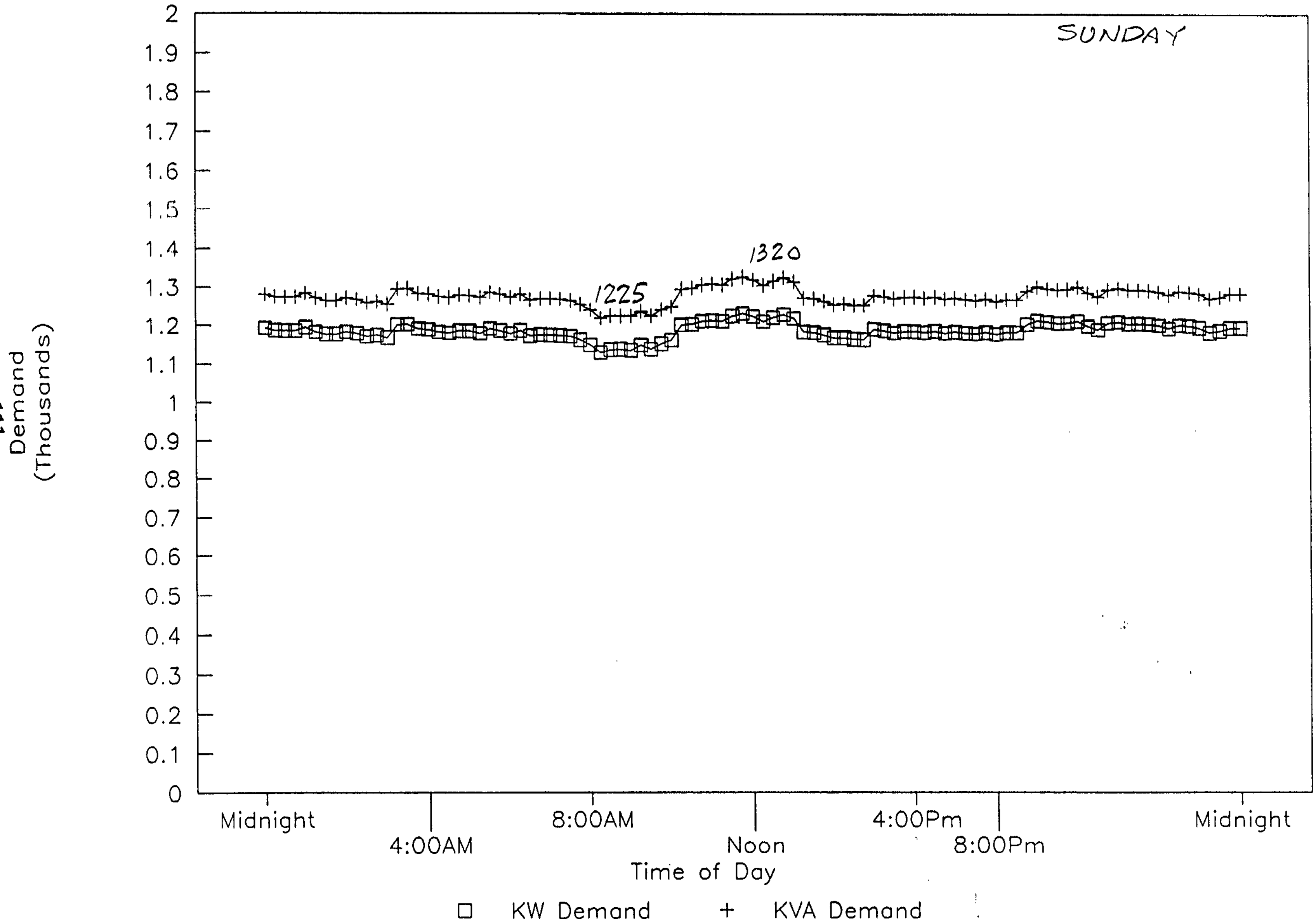
Lyster Total

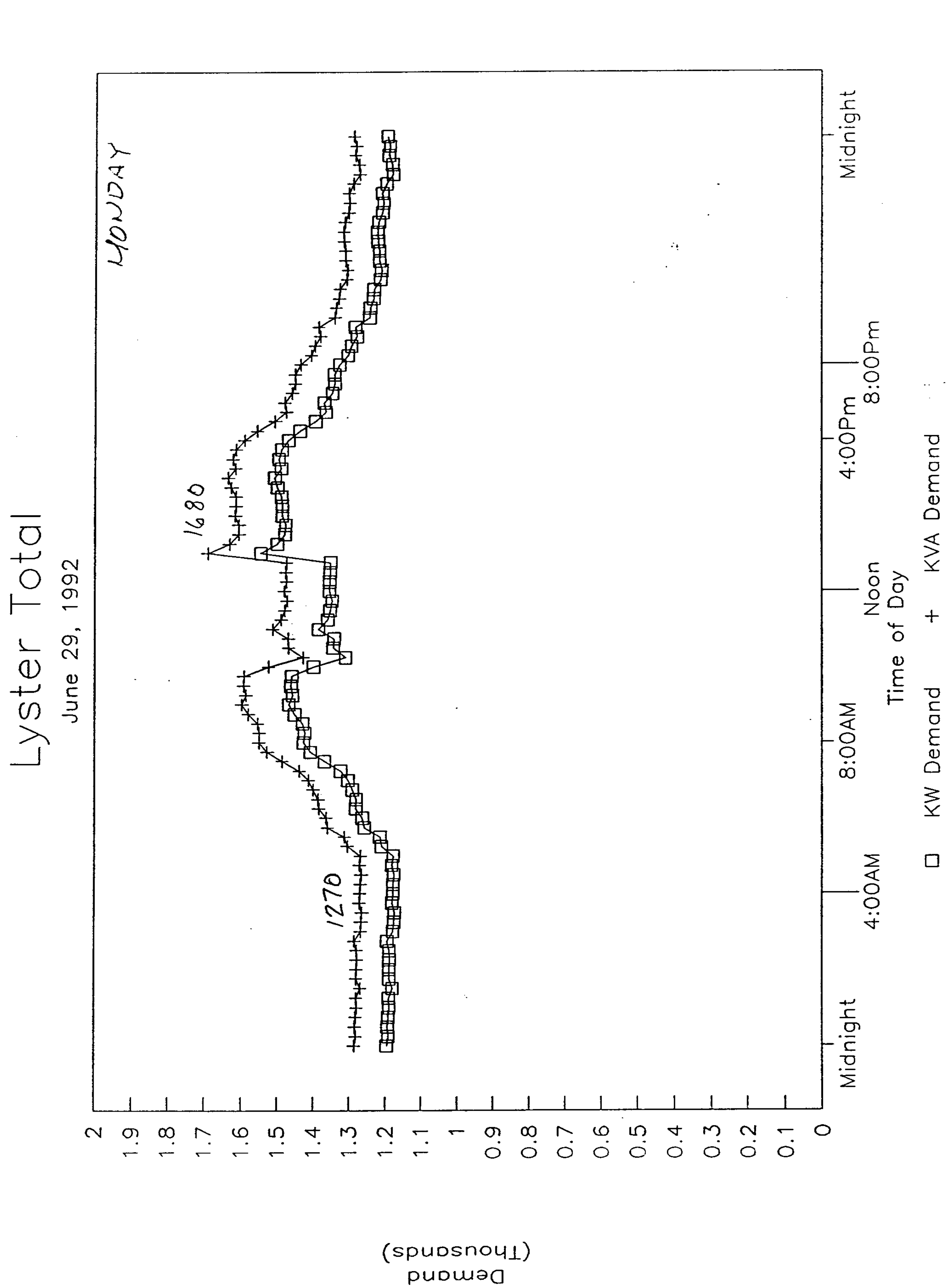
June 27, 1992

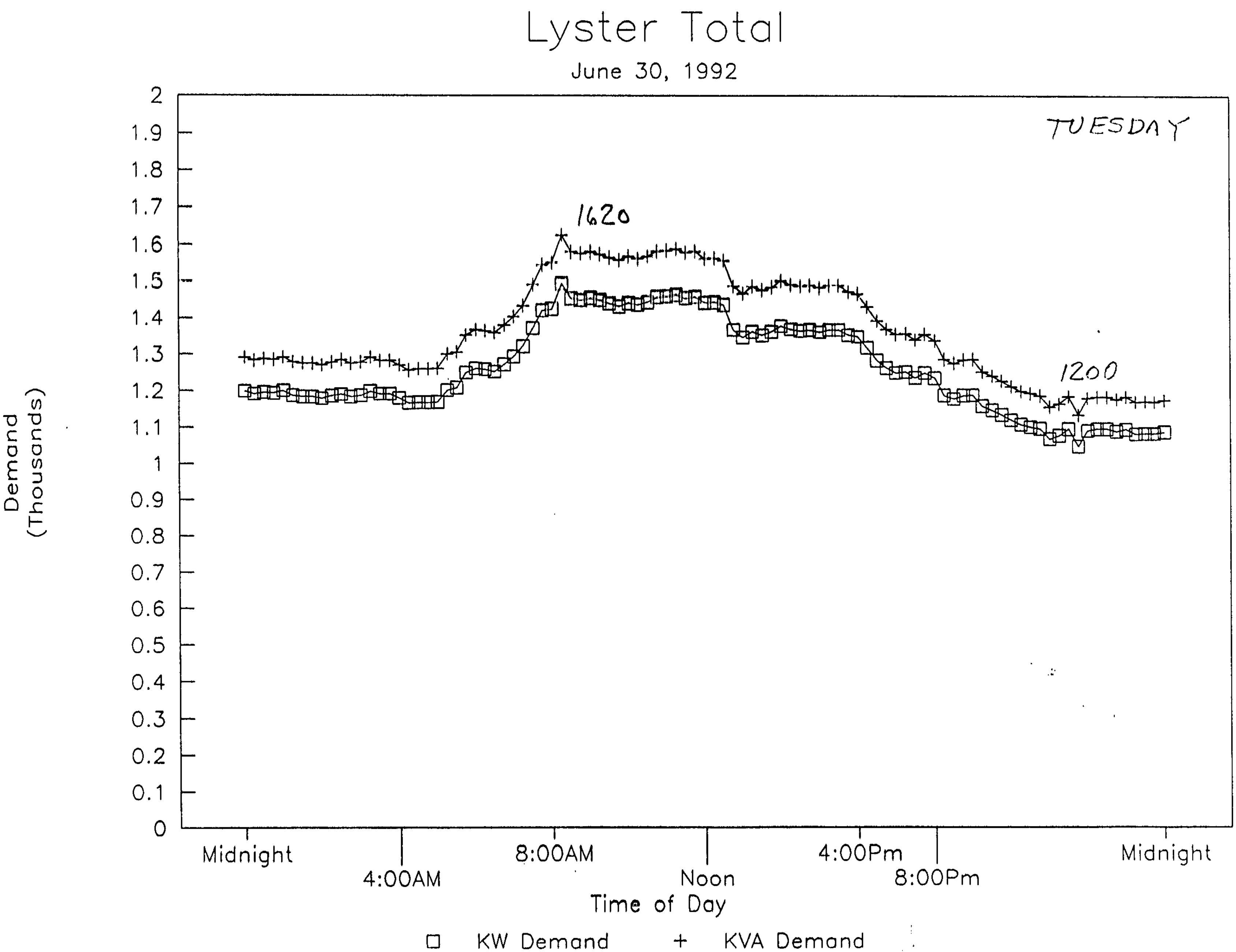


Lyster Total

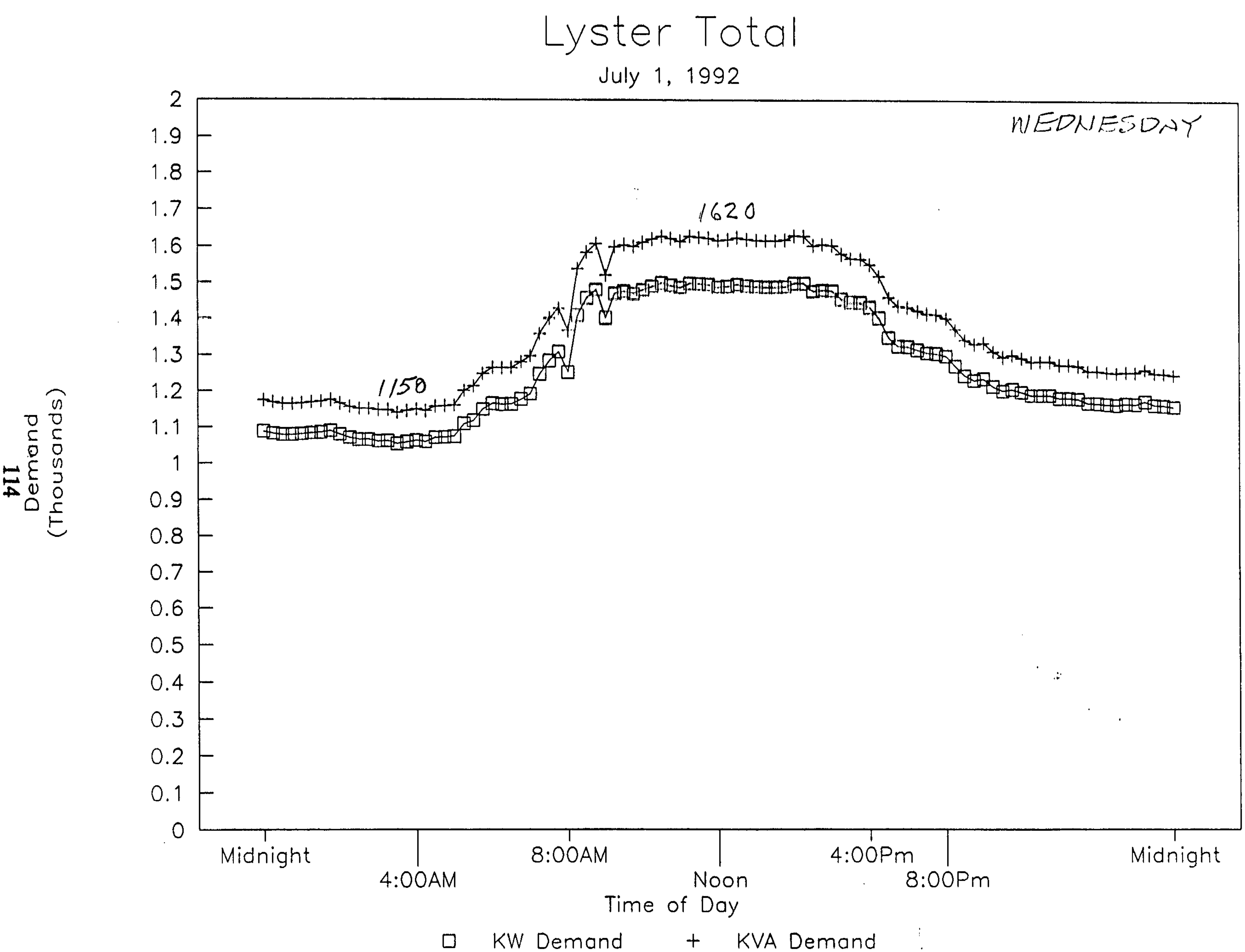
June 28, 1992




Lyster Total
June 29, 1992
MONDAY
1680
1270
Demand
(Thousands)
Time of Day
Midnight
4:00AM
8:00AM
Noon
4:00Pm
8:00Pm
Midnight
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1
1.1
1.2
1.3
1.4
1.5
1.6
1.7
1.8
1.9
2
KW Demand
KVA Demand



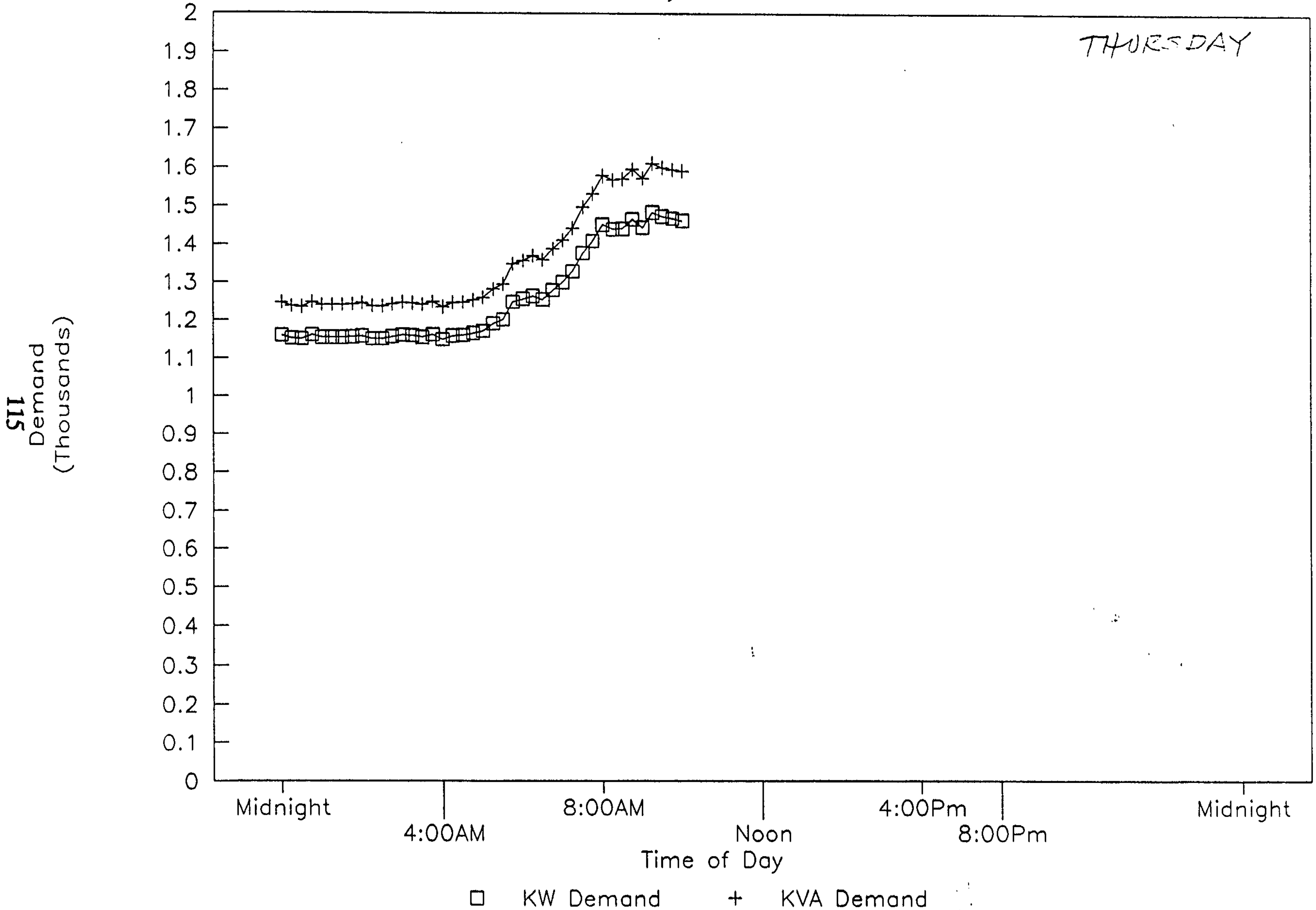
Lyster Total
June 30, 1992
TUESDAY
1620
1200
2
1.9
1.8
1.7
1.6
1.5
1.4
1.3
1.2
1.1
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
Demand
(Thousands)
Midnight
4:00AM
8:00AM
Noon
4:00Pm
8:00Pm
Midnight
Time of Day
KW Demand
KVA Demand



Lyster Total
July 1, 1992
WEDNESDAY
1620
1150
Demand (Thousands)
2
1.9
1.8
1.7
1.6
1.5
1.4
1.3
1.2
1.1
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
Midnight
4:00AM
8:00AM
Noon
4:00Pm
8:00Pm
Midnight
Time of Day
KW Demand
KVA Demand

Lyster Total

July 2, 1992



APPENDIX 4D

LESSONS FROM FIELD DEMONSTRATION AND TESTING OF STORAGE COOLING SYSTEMS

DEPARTMENT OF THE ARMY

FACILITY ENGINEERING

TECHNICAL NOTE NO. 5-670-1

DEPARTMENT OF THE ARMY
U.S. Army Engineering and Housing Support Center
Fort Belvoir, VA 22060-5516

Technical Note
No. 5-670-1

16 April 1992

FACILITIES ENGINEERING
Energy Storage Systems

LESSONS FROM FIELD DEMONSTRATION AND TESTING OF STORAGE COOLING SYSTEMS

1. Purpose. The purpose of this Technical Note (TN) is to provide lessons learned from the field demonstration of three diurnal ice storage cooling systems at Fort Stewart, GA, Yuma Proving Ground, AZ, and Fort Bliss, TX; and a chilled water storage cooling system at the New Mexico State University (NMSU), Las Cruces, NM.

2. Applicability. This Technical Note applies to all Army facilities engineering activities.

3. Reference. Technical Manual (TM) 5-670, Refrigeration, Air Conditioning, Mechanical Ventilation, and Evaporative Cooling, February 1962.

4. Background. For the majority of Army installations, the demand portion of the electrical utility bill is estimated between 30 and 50 percent. An Army installation has a number of unique characteristics favorable for storage cooling systems (SCS). To verify the applicability of SCS to Army facilities, the U.S. Army Engineering and Housing Support Center (EHSC) funded the U.S. Army Construction Engineering Research Laboratory (USACERL) to demonstrate three generic diurnal ice storage (DIS) cooling systems: Fort Stewart, in 1987 (ice-in-tank system, also known as the brine system); Yuma Proving Ground (YPG), in 1988 (ice-on-coil system); and Fort Bliss, in 1990 (ice harvester system, also known as ice shucking or dynamic system). During the cooling season of 1990, USACERL and NMSU monitored the performance of a 3-million gallon chilled water storage cooling system for cooling the NMSU campus.

5. Discussion. Although an ice storage cooling system can be designed following the routine guidelines for a conventional cooling system, particular attention must be paid to sizing of the "shift window," storage capacity, compressor derating, short cycling, construction labor costs, and system operation and maintenance. Appendix A contains a discussion of these factors for the demonstration sites. A chilled water storage cooling system can be operated under either chiller priority or tank

priority. System operation and maintenance, system performance, and economic performance of these two methods of operation are also discussed in appendix A.

6. Conclusions.

a. The efficacy of storage cooling systems to reduce electric demand costs of providing air conditioning to Army facilities has been verified in the field. The most cost-effective applications are for new construction and for replacement of existing cooling systems. For these applications, storage cooling systems are encouraged.

b. Ice storage cooling systems save the electric demand costs, but increase energy consumption up to 30 percent. Due to the energy penalty and the insensitivity of the economy of scale in the system first cost, ice storage cooling systems are recommended only for small to medium storage capacity systems (up to 2000 ton-hours).

c. Chilled water storage cooling systems save the electric demand costs as well as conserve energy up to 20 percent. Due to the economy of scale in the system first cost, chilled water storage cooling systems are not recommended for small storage capacity systems (under 1000 ton-hours).

7. Point of contact. Questions and/or comments regarding this subject, which cannot be resolved at installation or MACOM level, should be directed to U.S. Army Engineering and Housing Support Center, Directorate of Public Works, CEHSC-FU-M, Fort Belvoir, VA 22060-5516, at (703) 704-1552, AUTOVON 654-1552 or PAX ID CEHSCFUM. The USACERL point of contact is CECER-ES (217) 398-5433.

FOR THE DIRECTOR:

Frank J. Schmid

FRANK J. SCHMID
Acting Director
Directorate of Public
Works

APPENDIX A

Storage Cooling Systems

1. Ice Storage Cooling System.

a. Demonstration system descriptions. Summaries of project data for Fort Stewart, Yuma Proving Ground, and Fort Bliss, are presented in tables A-1, A-2, and A-3, respectively.

b. Feasibility. The feasibility of a system can be quantified by the payback period. The payback period depends on the savings in demand charges and the system first cost. The ice storage cooling systems reduce the electric demand costs but not energy costs and usage.

(1) Demand savings. The demand cost savings depend on the electric rate structure of each Army installation. Rarely do two installations have the same rate structures. (Note that there are over 3000 electric utility companies in the United States) For example, to calculate typical annual demand cost savings per each kilowatt shifted from onpeak to offpeak periods, assume the demand charge is $10/kW with an 80 percent ratchet clause. For the 5 summer months (May through September), the demand cost is $50 (1 kW * $10/kW/m * 5 m). For the 7 nonsummer months (October through April), the demand cost is $56 (0.8 * 1 kW * $10/kW/m * 7 m). Therefore, the specific annual savings due to shifting 1 kW from onpeak to offpeak periods is $106/kW/yr. The total savings can be obtained by calculating the product of the total power shifted in kW multiplied by the specific annual savings in $/kW/yr. The three demonstration systems shift 122 kW, 157 kW, and 105 kW from onpeak to offpeak for Fort Stewart, YPG, and Fort Bliss, respectively. Based on the rate schedules for these locations, the actual savings are $10,132/yr, $22,450/yr, and $21,000/yr for Fort Stewart, YPG, and Fort Bliss, respectively. The cost of the energy penalty has been included in the calculation for YPG. Although the Fort Bliss system shifts less power (105kW) than the Fort Stewart system (122kW), the actual savings by the Fort Bliss system is more than twice as much as the Fort Stewart system because the demand charge for Fort Bliss is $19.50/kW whereas the demand charge for Fort Stewart is only $7.00/kW. Other factors affecting the savings are the ratchet schedule, the time-of-use rate, and the power band blocks.

(2) System first cost. The system first cost consists of three roughly equal parts: (1) condensing unit (i.e., icemaker) cost, (2) storage tank cost, and (3) installation labor cost. Depending on the type of application (i.e., new construction, replacement, or retrofit application), the first

APPENDIX A

Storage Cooling Systems

1. Ice Storage Cooling System.

a. Demonstration system descriptions. Summaries of project data for Fort Stewart, Yuma Proving Ground, and Fort Bliss, are presented in tables A-1, A-2, and A-3, respectively.

b. Feasibility. The feasibility of a system can be quantified by the payback period. The payback period depends on the savings in demand charges and the system first cost. The ice storage cooling systems reduce the electric demand costs but not energy costs and usage.

(1) Demand savings. The demand cost savings depend on the electric rate structure of each Army installation. Rarely do two installations have the same rate structures. (Note that there are over 3000 electric utility companies in the United States) For example, to calculate typical annual demand cost savings per each kilowatt shifted from onpeak to offpeak periods, assume the demand charge is $10/kW with an 80 percent ratchet clause. For the 5 summer months (May through September), the demand cost is $50 (1 kW * $10/kW/m * 5 m). For the 7 nonsummer months (October through April), the demand cost is $56 (0.8 * 1 kW * $10/kW/m * 7 m). Therefore, the specific annual savings due to shifting 1 kW from onpeak to offpeak periods is $106/kW/yr. The total savings can be obtained by calculating the product of the total power shifted in kW multiplied by the specific annual savings in $/kW/yr. The three demonstration systems shift 122 kW, 157 kW, and 105 kW from onpeak to offpeak for Fort Stewart, YPG, and Fort Bliss, respectively. Based on the rate schedules for these locations, the actual savings are $10,132/yr, $22,450/yr, and $21,000/yr for Fort Stewart, YPG, and Fort Bliss, respectively. The cost of the energy penalty has been included in the calculation for YPG. Although the Fort Bliss system shifts less power (105kW) than the Fort Stewart system (122kW), the actual savings by the Fort Bliss system is more than twice as much as the Fort Stewart system because the demand charge for Fort Bliss is $19.50/kW whereas the demand charge for Fort Stewart is only $7.00/kW. Other factors affecting the savings are the ratchet schedule, the time-of-use rate, and the power band blocks.

(2) System first cost. The system first cost consists of three roughly equal parts: (1) condensing unit (i.e., icemaker) cost, (2) storage tank cost, and (3) installation labor cost. Depending on the type of application (i.e., new construction, replacement, or retrofit application), the first

cost varies significantly. For new construction or a replacement application, only the cost of the storage tank should be used for calculating the payback period. For these applications, the costs for the chiller and installation labor are the same for a conventional system and a storage cooling system. For a retrofit application, on the other hand, the existing chiller may not produce ice. A new icemaker must be purchased and installed along with the storage tank. Table A-4 lists the actual system first costs paid for the three demonstration systems. Note that the installation labor costs for the demonstration system were 41 percent, 63 percent, and 84 percent of the total construction cost for Fort Stewart, YPG, and Fort Bliss, respectively. USACERL hired the Science Applications International Corporation (SAIC), an independent private consulting company, to investigate the causes of such high installation labor costs. The major causes cited by SAIC are as follows:

(a) System sizes are small. Therefore, the relative contribution of the labor cost is high.

(b) Systems are retrofits instead of new installations.

(c) High markups on Government projects.

(d) Overbid by contractors inexperienced in storage cooling systems.

It should be remembered that these causes are not unique to the demonstration systems. Retrofit application of storage cooling systems is expensive. If the storage systems are installed for new constructions or replacing old cooling systems, the net cost of the storage cooling systems will be the cost of the storage tank only. Even for a conventional cooling system, the condensing unit must be bought and the installation labor cost must be paid. Recalculating the payback periods of the three demonstration systems based only on the cost of the storage tanks, would yield 5.2, 2.7, and 1.2 years for Fort Stewart, YPG, and Fort Bliss, respectively. Incentive programs available from the electric utility, would reduce the system first cost substantially. For the Yuma Proving Ground (YPG), system, the incentive from the Arizona Public Service covered more than 20 percent of the total system cost.

Table A-1. Fort Stewart System Project Summary

Project Chronology

Date	Event
01 Oct 85	Project authorized.
01 Nov 85	Fort Stewart, GA was selected to be the demo site. Initial project conference at Fort Stewart.
27 Nov 85	ORNL's system design and draft construction specifications completed and sent to Fort Stewart.
06 Feb 86	Project advertised through the Commerce Business Daily by Fort Stewart.
12 Feb 86	ORNL initiated major equipment procurement process.
07 May 86	Construction specifications completed, and RFP issued by Fort Stewart.
09 Jun 86	Bid opening (3 bids received).
10 Jul 86	Major equipment delivered to Fort Stewart.
20 Jul 86	Contract awarded to Erickson's, Inc.
01 Aug 86	Preconstruction conference and Notice to Proceed issued.
07 Nov 86	Preacceptance test.
01 Apr 87	Final acceptance of system by Fort Stewart.

Design and Construction

Type of design	Retrofit, demand-limiting storage
Facility (PX) floor area	51,000 sq ft
Chiller shutoff window	1200-1800 hours
Minimum storage capacity	700 ton-hr
Storage tank	10 in two rows (Calmac Model 2090)
Nominal storage capacity	900 ton-hr
Maximum discharge rate	136 ton
Charging time	10 hrs
Coolant	25 percent brine (ethylene glycol)
Entering brine temperature	25 F
Icemaker	Reciprocating chiller (Trane CGWB-D18E), designed for 175 ton unit, 200 ton unit delivered and installed

Measured System Energy Performance

Peak power shifted	122 kW
Icemaker kW/ton ratio	0.96 kW/ton (direct cooling) 1.19 kW/ton (storage cooling)

System Economics

System first cost	$153,295
Annual savings	$10,132/yr
Payback period	15 yrs

Table A-2. YPG System Project Summary

Project Chronology

Date	Event
01 Oct 86	Project authorized.
18 Dec 86	Building #506, YPG selected.
10 Mar 87	ORNL draft design/bid specifications to YPG.
21 Apr 87	Specs completed; contracting process began.
06 Jul 87	Four bids were opened ($222K, $237K, $223K, and $269K)
15 Jul 87	Bids were rejected on the basis of lack of funds. Separation of hardware procurement and system installation. Storage tank and heat exchanger were to be procured by USACERL.
05 Nov 87	Revised draft bid package to YPG.
15 Dec 87	Hardware contract to Roger L. Echelmeir Co. ($68,034).
02 Mar 88	Hardware shipped from factory to YPG.
22 Mar 88	Five bids were opened at YPG ($234K, $179,281, $159K, $135,679, and $114,435)
10 May 88	AT Mechanical, the lowest bidder, was awarded installation contract ($114,435); preconstruction conference at YPG; and Notice to Proceed issued.
05 Aug 88	Preliminary system performance testing completed.
25 Aug 88	Formal acceptance of system by YPG.

Design and Construction

Type of design	Retrofit, demand-limiting storage
Facility floor area	86,100 sq ft
Chiller shutoff window	1200-1600 hours
Design tank capacity	900 ton-hr
Storage tank	One tank (BAC Model TSU-1050C)
Nominal tank capacity	1050 ton-hr
Charging time	maximum 20 hrs
Coolant	30 percent brine (ethylene glycol)
Entering brine temperature	25 F
Icemaker	Existing reciprocating chiller (YORK Model LCHA-85-46C, Nominal capacity as water cooler - 85 ton; as icemaker - 45 ton)

Measured System Energy Performance

Peak power shifted	157 kW
Icemaker kW/ton ratio	2.72 kW/ton (seasonal average)

System Economics

Gross system first cost	$182,469
Incentive award from utility	$37,500
Net system first cost	$144,969
Net annual savings	$22,450
Simple payback period	6.5 yrs

Table A-3. Fort Bliss System Project Summary

Project chronology

Date	Event
17 Nov 87	Icemaker (laboratory tested at ORNL) purchased.
01 Oct 88	Fort Bliss project authorized.
18 Nov 88	ORNL's system design and draft construction specifications completed and delivered to Fort Bliss.
25 May 89	Project advertised through the Commerce Business Daily by Fort Bliss.
23 Jun 89	Bid opening; 3 bids received ($129K, $130K, and $167K).
01 Jul 89	Icemaker delivered to Fort Bliss.
08 Sep 89	Contract awarded to Graham Construction, Co. Notice to Proceed issued.
31 May 90	Acceptance test.
01 Aug 90	Final acceptance of system by Fort Bliss.
19 Nov 90	System performance monitoring completed.

Design and Construction

Type of design	Retrofit, Demand-limiting storage
Facility floor area	18,500 sq Ft
Chiller shutoff window	1200-1600 hours
Design tank capacity	300 ton-hr
Storage tank	One steel tank, above ground
Charging time	Maximum 12 hrs
Icemaker	40-ton water cooling 26-ton ice making (Dynamic Icemaker Unit Model HP 300 ASC, Royce Compressor Model #CG040)

Measured System Energy Performance

Peak power shifted	105 kW
Icemaker kW/ton ratio*	1.94 kW/ton
Chiller kW/ton ratio	1.50 kW/ton (conventional cooling)

System Economics

Gross system first cost	$153,999
Annual savings	$21,000
Expected payback period	7.3 yrs

*Energy performance of the icemaker has been tested at the Oak Ridge National Laboratory prior to field installation. The ORNL data ranged from 1.25 to 1.60 kW/ton. The ORNL testing was performed in a laboratory environment with the tank installed indoors.

Table A-4. Demonstration System Actual Costs

Location	Fort Stewart	YPG	Fort Bliss
Government Furnished Material Costs			
Chiller/Ice Harvester	$52,793	*	$24,990
Heat Exchanger	15,935	7,836	**
Storage Tank(s)	53,460	60,198	***
Subtotal	122,188	68,034	24,990
Contractor Installation Costs	83,900	114,435	129,000
Total Costs (rounded)	$206,000	$182,000	$154,000

* Existing reciprocating chiller was converted into an icemaker.
** The heat exchanger is not needed in this system.
***The bid specifications required the contractor to procure and install the tank. Therefore, the cost of the tank is included in the system installation cost.

(3) Feasibility study tool. A draft version of a user-friendly PC software program (STOFEAS) has been prepared by USACERL. Required inputs are the installation electric demand information and the local rates. A set of default system first costs have been built into the program. The default costs can be modified by the user if better cost data are available. STOFEAS analyzes the economic feasibility of the storage cooling system shifting 1 to 15 percent of the peak power demand of an installation from onpeak to offpeak periods.

c. System Design and Construction. A storage cooling system can be designed following the routine guidelines for a conventional cooling system. Particular attention is required for the following areas.

(1) Sizing of the "shift window" and storage capacity. Most Army installations are centrally metered by a master meter. Selection of the shift window (the length of time during which power consumption is shifted from onpeak to offpeak) must be determined from the master meter demand profile, not from the candidate building cooling demand profile. The window should be large enough to contain the peak in the master meter demand profile. Excessive window size, however, would result in increased system first cost and a longer payback period. The capacity of the storage tank can be determined from the selected period of shift and the amount of the peak demand to be shifted during that time interval.

(2) Compressor derating. In an icemaking operation, the compressors rated for water cooling are significantly derated (about 30 percent). The operating conditions under which compressors are rated must be carefully reviewed. Generous sizing of the compressors, evaporators, and storage is recommended.

(3) Short cycling. Short cycling of compressors may be a problem (as experienced by the Fort Stewart, system in an early phase of operation) after the tank is fully charged with ice. This results from the fluid temperatures in the piping system causing the compressor to turn off after making ice. In some systems, a full charge of ice results in a significant lowering of the return water temperature, which deactivates the compressor. After a while, the water temperature in the pipe may rise due to ambient heat gain and the compressor would be turned on. A control unit based on the ice inventory resolves this problem.

(4) Construction labor cost. The labor cost for field installation of an ice storage system is high. Savings in installation costs by using prepackaged or modular systems could be significant. However, for larger systems (storage capacity over 2000 ton-hours), the modular systems may require multiple tanks. Extensive piping could adversely affect the system first cost as well as future operation and maintenance.

d. System operation and maintenance. The storage cooling system requires no particular operation and maintenance practices other than those required by conventional cooling systems. One specific concern in the maintenance of the storage cooling system is that it is often installed outdoors because the storage tank (especially in a retrofit application) is too large to fit inside the mechanical room. The piping loop containing chilled water or condenser water must be protected from freezing either by draining or by heat tape. The following maintenance problems were experienced during the operation of the three demonstration ice storage cooling systems.

(1) Fort Stewart system.

(a) This system has 10 storage tanks connected by a set of main supply and return headers. Figure 1 is a schematic diagram of the system and figure 2 is a photograph of the system. The header moved slightly when priming the main circulation pump. This motion caused stress on the rigid connecting tubes (PVC tubing) between the header and the nipples of the tank. Eventually, a number of the PVC connectors developed hairline cracks and antifreeze leaked out. The problem was solved by replacing the rigid PVC tubing with flexible rubber tubing.

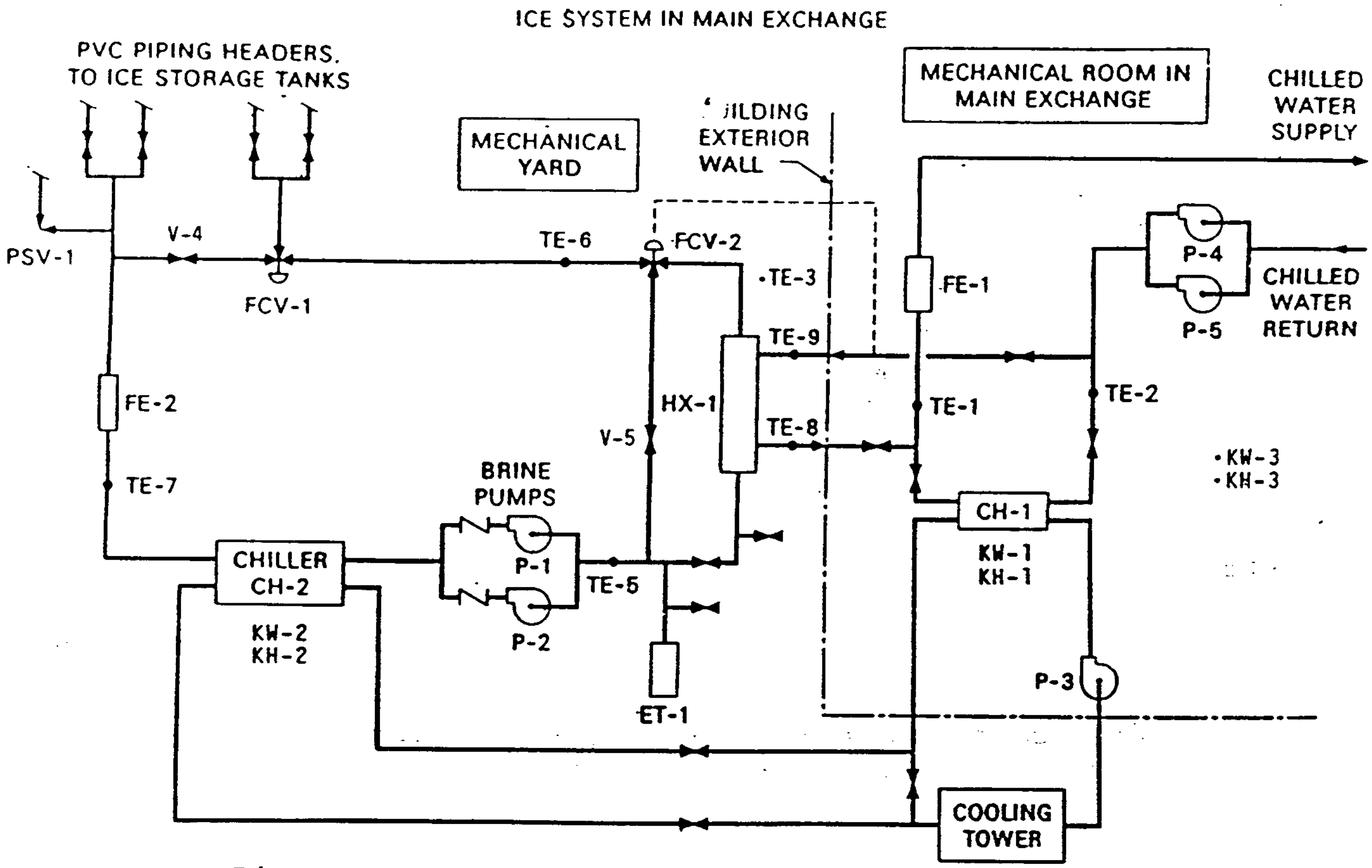


Figure 1. Fort Stewart system diagram

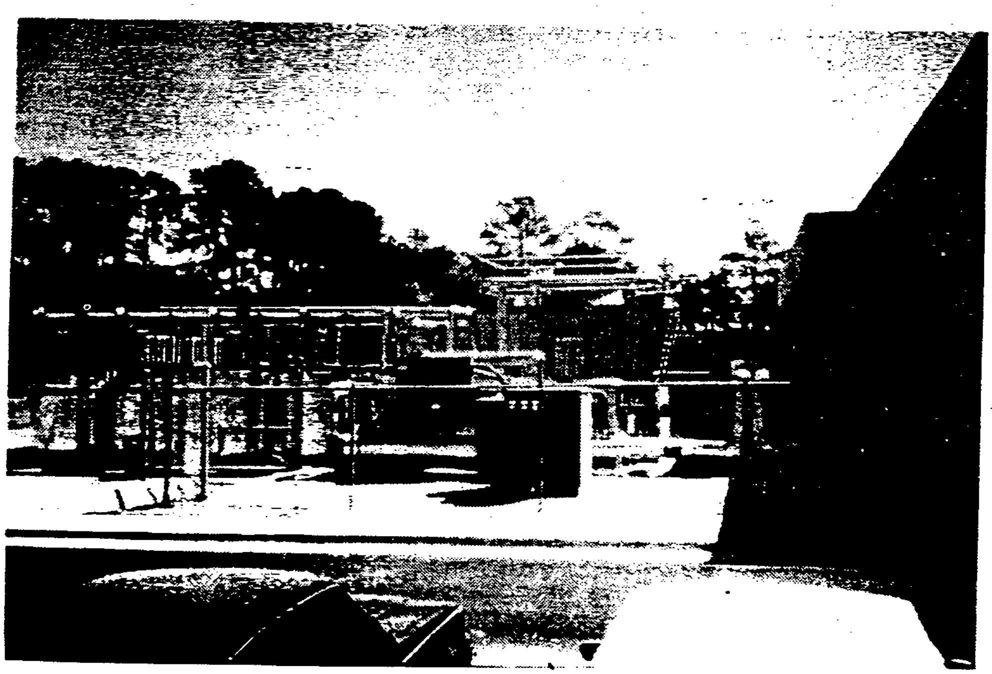


Figure 2. Fort Stewart system

(b) During the winter of 1989, the condenser loop was not drained. The water in the condenser barrel froze and ruptured the condenser coils. Through the ruptured coils, moisture migrated into the cylinders of the icemaker compressor. The coils in the condenser barrel and the compressors had to be repaired.

(2) YPG system.

(a) During the first few weeks of operation in August 1988, an air blower for the ice storage tank failed. The blower agitates the water in the tank to achieve uniform freezing and melting of ice on the coil in the tank. The manufacturer replaced it under warranty.

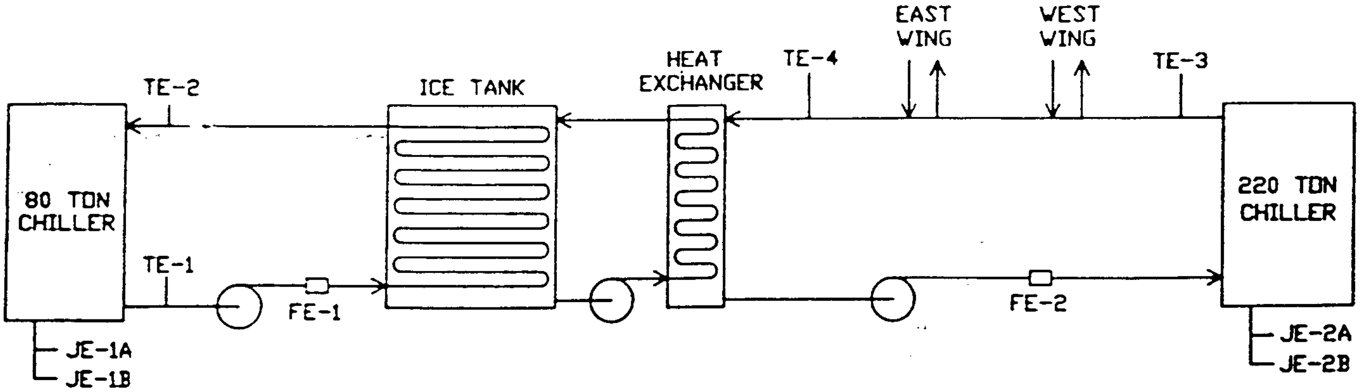
(b) In June 1989, the high pressure switch of the icemaker tripped the compressor a number of times, resulting in no ice being made in the tank. The icemaker has an air-cooled condenser, which is partly blocked by a decorating wall. Cleaning the air passage to the condenser coil and supplying more air with an external fan brought down the condenser operating temperature, and resolved the problem. Note that this was a typical condenser cooling problem, not related to the storage cooling system. Figure 3 is a schematic diagram of the system and figure 4 shows a photograph of the system.

(3) Fort Bliss system.

(a) During the commissioning period of the system in July 1990, the conventional chiller experienced short cycling while the ice storage cooled the building. Correcting the interface of the ice system control with the chiller control resolved the problem.

(b) In June 1991, the icemaker leaked refrigerant through a ruptured pressure gauge. The pressure gauge was replaced, and the system was recharged with refrigerant. This could happen to any refrigeration system, and is not particularly related to the ice storage cooling operation. Figure 5 is a schematic diagram of the system and figure 6 shows a photograph of the system.

e. System performance. Each demonstration system has been instrumented to collect data on demand shift capability and energy performance. The typical daily performance of each system is shown in figures 7, 8, and 9 for Fort Stewart, YPG, and Fort Bliss, respectively.



CHAN	LABEL	DESCRIPTION
101	TE-1	BRINE SUPPLY TEMPERATURE TO ICE TANK
102	TE-2	BRINE RETURN TEMPERATURE FROM ICE TANK
103	TE-3	CHILLED WATER SUPPLY TEMPERATURE TO BUILDING
104	TE-4	CHILLED WATER RETURN TEMPERATURE FROM BUILDING
105	TE-5	OUTSIDE AIR TEMPERATURE
106	TE-6	INSIDE AIR TEMPERATURE
107	JE-1A	80 TON CHILLER DEMAND (KW)
108	JE-2A	220 TON CHILLER DEMAND (KW)
109	JE-1B	80 TON CHILLER ENERGY (KW-HR/15 MIN)
110	JE-2B	220 TON CHILLER ENERGY (KW-HR/15 MIN)
111	FE-1	BRINE FLOW RATE (GAL/15 MIN)
112	FE-2	CHILLED WATER FLOW RATE (GAL/15 MIN)

Figure 3. YPG system diagram

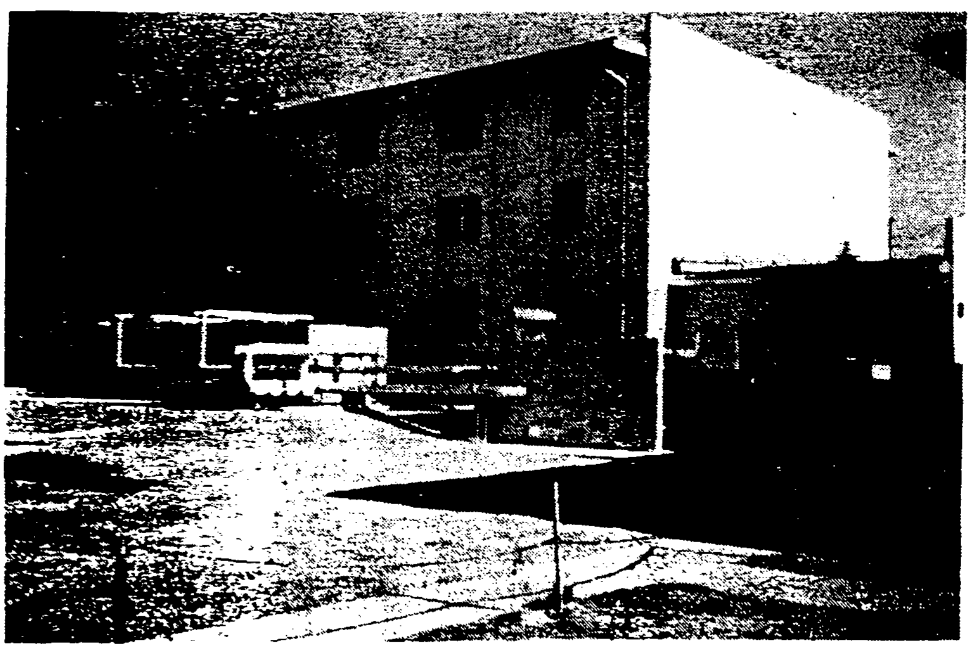
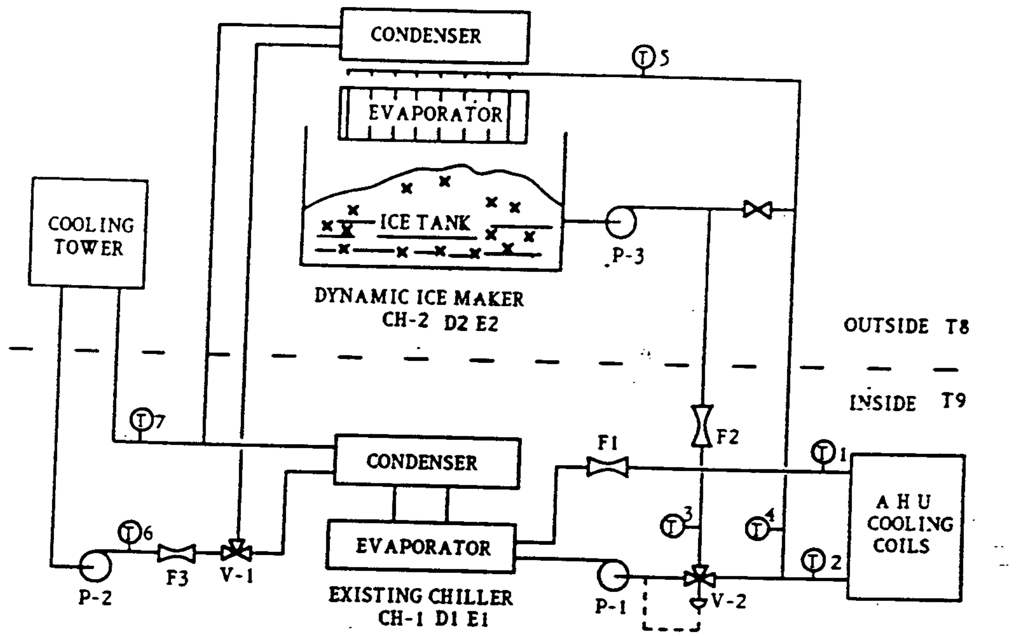


Figure 4. YPG system



T1 - Chilled Water Supply Temp
T2 - Chilled Water Return Temp
T3 - Ice Water Supply Temp
T4 - Ice Water Return Temp
T5 - Ice Water Recirc Temp
T6 - Cond Supply Water Temp
T7 - Cond Return Water Temp
T8 - Outside Air Temp
T9 - Inside Air Temp

D1 - Existing Chilled Demand (kW)
D2 - Ice Water Demand (kW)

E1 - Existing Chiller Energy (kW-hr)
E2 - Ice Maker Energy (kw-hr)

F1 - Chilled Water Flow Rate (gpm)
F2 - Ice Water Flow Rate (gpm)
F3 - Cond Water Flow Rate (gpm)

Figure 5. Fort Bliss system diagram

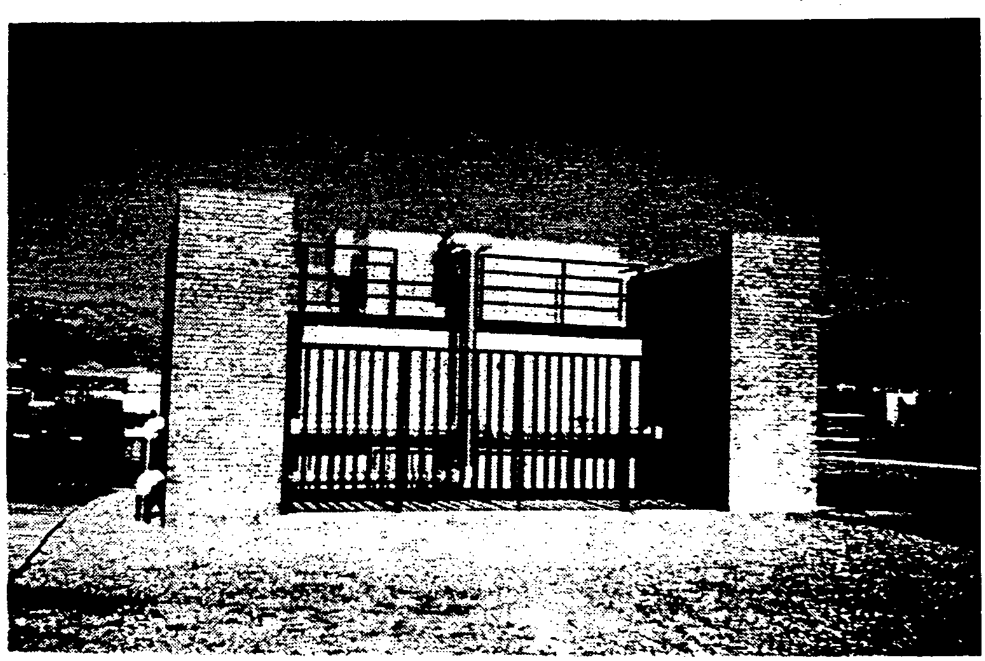


Figure 6. Fort Bliss system

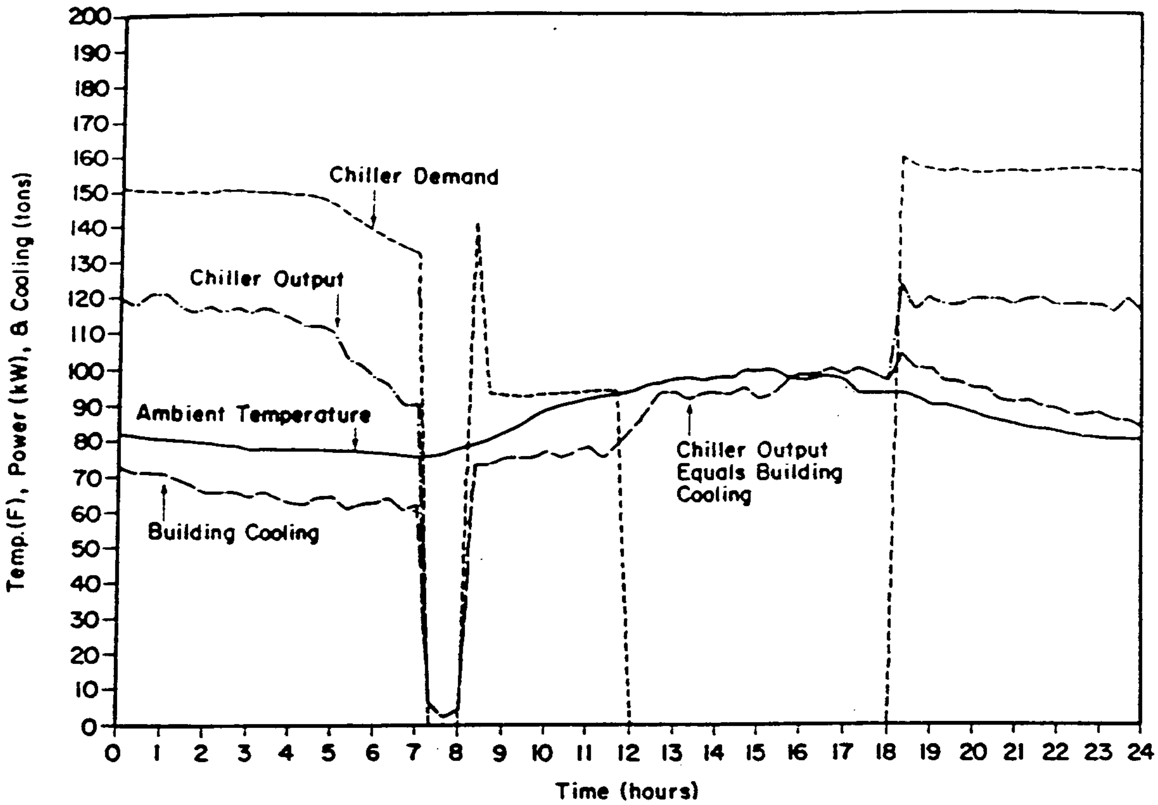


Figure 7. Fort Stewart system performance results

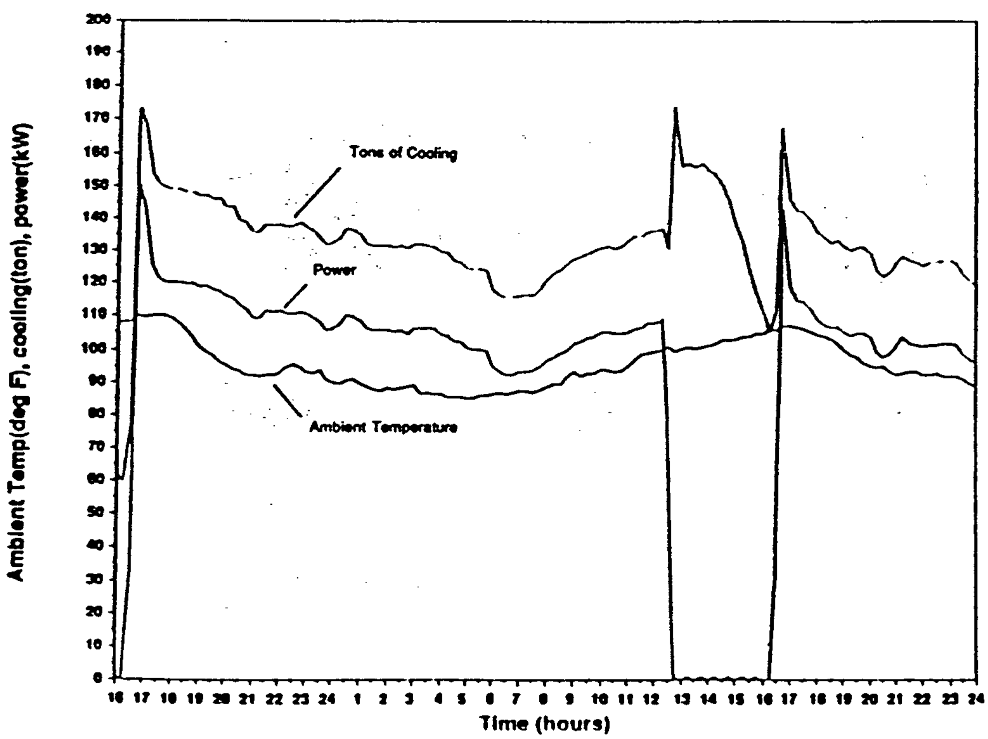


Figure 8. YPG system performance results

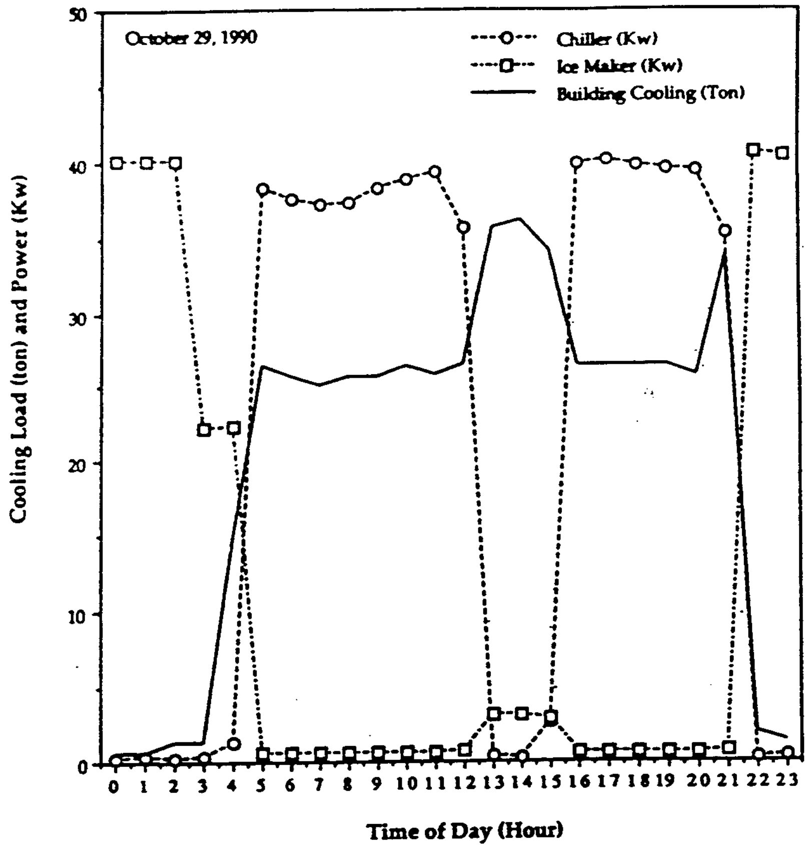


Figure 9. Fort Bliss system performance results

(1) Demand shift from onpeak to offpeak periods. All three demonstration systems successfully shifted electric demands for cooling from onpeak (shift window) to offpeak periods (nighttime). The demand reduction was 120 kW for Fort Stewart, 157 kW for YPG, and 105 kW for Fort Bliss.

(2) Energy performance. The energy performance of the demonstration systems was measured in terms of the power consumption factor (in kW/ton ratio). The power consumption factors of conventional cooling chillers were also measured to compare the energy performance between conventional and ice storage cooling systems. The results are 1.39 kW/ton (ice) and 1.18 kW/ton (conventional) for the Fort Bliss system, 2.72 kW/ton (ice) and 0.82 kW/ton (conventional) for the YPG system, and 1.94 kW/ton (ice) and 1.50 kW/ton (conventional) for the Fort Bliss system. The data from the YPG system is not significant, because the conventional chiller is a new, water-cooled, relatively large capacity (220-ton) centrifugal chiller, whereas the icemaker is an old (more than 10 years old), air-cooled, small (four compressors of 20-ton capacity each) reciprocating chiller. The new icemaker at Fort Stewart is the same type and same capacity as the existing chiller. The new icemaker at Fort Bliss is the

same type with a capacity similar to the existing chiller. In these two systems, the energy penalty was 18 and 29 percent compared to the conventional chillers.

(3) Economic performance. Economic performance of the demonstration systems is measured in terms of the system payback period. The payback period was calculated based on the system first cost and the annual savings in demand charges. The calculated results are 20, 6.5, and 7.3 years for the Fort Stewart, YPG, and Fort Bliss systems, respectively. Note that the goal of the Fort Stewart system was the demonstration of the technical feasibility, rather than the economic feasibility, of the ice storage cooling technology. Also note that all three systems were retrofit applications, which is the least cost-effective application. If these systems were for new systems or replacement applications, the payback period would be 5.3, 2.7, and 1.2 years for the Fort Stewart, YPG, and Fort Bliss systems, respectively.

2. Chilled water storage cooling system.

a. Background. A chilled water storage cooling system is an alternative to reduce the electric demand costs in space air-conditioning. During the cooling season of 1990, USACERL and the Department of Mechanical Engineering, New Mexico State University (NMSU), Las Cruces, NM, monitored the performance of a 3-million gallon storage capacity chilled water storage cooling system cooling the NMSU campus. The purpose of the project was to measure the energy performance and obtain field experience from a typical operating chilled water storage cooling system.

b. NMSU system description. The NMSU campus of 48 buildings is cooled by a central cooling plant (with three chillers of 1000- 1500- and 1500-ton capacity) like an Army installation with a central cooling plant. In 1985, the campus cooling load approached the capacity of the cooling plant. NMSU had two options: (1) build an additional cooling plant at a cost of $2.5 million, or (2) install a chilled water storage system to increase the cooling capacity of the existing plant. The second option was selected and a 3-million gallon stratified chilled water storage tank was installed in 1986 at a total cost of $3.25 million. The nominal storage capacity is 20,000 ton-hours, with a peak tank discharge rate of 2300 tons.

c. System operation and maintenance. Two strategies are available for system operation. One is the chiller priority and the other is the tank priority operation. The concept and the field experience of these strategies from the NMSU system are discussed in the following paragraphs.

(1) Chiller priority operation. By 0600 hours, the tank is fully charged. The campus cooling load starts to rise from 0700 hours. Two cooling sources are used to meet the load. One is the stored chilled water in the tank and the other is the chiller in the plant. In the chiller priority operation, the chiller meets the load first until the campus cooling load exceeds the cooling capacity of the chiller in the plant. The extra cooling requirement beyond the capacity of the chiller is met by the chilled water stored in the tank. In this way, the operator always keeps a reserve cooling capacity and is prepared for any emergencies, such as a failure of a chiller. If a chiller fails, the shortfall can be met by the chilled water stored in the tank while the failed chiller is serviced. The tank serves as a standby chiller ready to meet the extra cooling load that cannot be satisfied by the chillers. The disadvantage of this chiller priority, however, is that the chilled water stored in the tank is not fully used on a daily cycle. This decreases the energy performance of the storage tank and does not maximize the electric demand reduction potential.

(2) Tank priority operation. At the beginning of the preselected shift window (during the utility onpeak period), the tank, rather than the chiller, meets the cooling load at the maximum discharge rate. If the campus cooling load becomes greater than the maximum cooling provided by the storage tank, the difference is met by the chiller. In such a way, use of the storage tank is maximized (i.e., better energy performance) and the chiller demand during the onpeak period is minimized (i.e., the maximum savings in the electric demand cost). This is the most typical operating strategy of a chilled water storage cooling system. One disadvantage from the point of view of the system operator is the loss of the reserve capacity.

d. System performance. During the 1990 cooling season, the NMSU system operated mainly on the chiller priority schedule. The NMSU Physical Plant Department was more concerned about providing reliable cooling to the campus than maximizing the demand cost savings potential of the system. Only on a few occasions (when one of the three chillers in the plant was down) did the tank fully discharge.

(1) Chiller priority operation. The seasonal average power consumption ratio of the NMSU storage cooling system during the monitoring period (March to August 1990) was 0.93 kW/ton. The overall system power consumption factor, including the conventional mode of operation, was 0.88 kW/ton. For typical chilled water storage, the power consumption of the storage mode operation is lower than that of convention cooling by about 20 percent. The energy conservation of a chilled water storage system occurs in two ways: (1) the typical nighttime ambient temperature is lower than the day temperature, which increases the refrigeration cycle coefficient-of-performance (COP) due to a lower condensing temperature, and (2) charging the storage tank

is a steady operation, not like cooling the building with a fluctuating cooling load. The COP of a fully loaded chiller in a steady-state operation (storage mode) is much higher than the COP of a part-loaded chiller in intermittent operation (conventional cooling mode). The reason for the high power consumption factor for the NMSU system in the storage cooling mode was the low duty cycle of the chillers in the storage mode. The seasonal average duty cycle of the chillers during the storage mode was 46 percent, and 58 percent while in the conventional cooling mode. Note that, under the chiller priority schedule, the chiller (rather than the storage) provided cooling in a fully-loaded condition during most of the afternoon hours.

(2) Tank priority operation. The energy efficiency of storage cooling (compared to conventional cooling) was observed on a number of occasions when the tank was fully discharged. During the charging period (the night immediately following the full discharge of tank during the day) the power consumption factor of the chiller was 0.78 kW/ton, which is about 11 percent lower than that of the seasonal average in the conventional cooling mode. Again, the favorable condensing conditions during the night and the steady operation of the chiller would make the chilled water storage cooling system conserve energy (up to 20 percent of the energy required by the conventional chiller operation) as well as shift the electric demand for cooling from onpeak to offpeak periods.

(3) Economic performance.

(a) Chiller priority. The maximum cooling load observed during the monitoring period was 4600 tons. Although the nominal rating of the three chillers was 4000 tons, the actual maximum output was 3500 tons. During the peak setting, therefore, the chilled water storage met 1100 tons of cooling load. Based on the power consumption factor of 0.88 kW/ton for a conventional cooling system, the storage system reduced the NMSU electric demand by 968 kW. Under the current demand charge of $19.50/kW with a 75 percent ratchet, reducing the electric demand by 968 kW amounts to an actual saving of demand cost of $193,500 for a year. The differential construction cost between an additional cooling plant and the chilled water storage was $0.75 million ($2.5 million vs $3.25 million). Therefore, the payback period of the NMSU chilled water storage system is 3.9 years.

(b) Tank priority. Note that the design discharge rate of the storage tank is 2300 tons. If the system is operated on the tank priority schedule, the demand shifting would be more than doubled (2300 tons instead of 1100 tons); this would also double the savings in electric demand costs.

e. Additional comment on the NMSU system. The primary goal of the NMSU chilled water storage cooling system was to increase the capacity of the central cooling plant. Even under the

conservative mode of system operation (chiller priority), the savings in the electric demand cost was significant enough to payback the system differential first cost within 4 years. Note that, however, if the NMSU system was for a retrofit application, the entire amount of the system cost ($3.25 million) should be used to calculate the payback period. In that case, even with an aggressive tank priority schedule for the maximum savings of the demand cost, the payback period would extend to 8 years. This shows a good example of cost effectiveness of an application of storage cooling system in a new construction or a replacement situation compared to a retrofit application.

3. System Selection.

a. Either ice or chilled water is suitable as a storage medium for a storage cooling system for Army facilities. The characteristics of each medium are compared in table A-5.

b. Ice systems are recommended for a small cooling plant (storage capacity up to 2000 ton-hours) that is not tied into a central cooling plant. The energy penalty for a small system is negligible compared to the benefit of reduced demand cost savings. For a larger system, however, the energy penalty should be weighed seriously in the system selection. Due to the economy of scale, a chilled water system is not recommended for smaller systems with a storage capacity under 1000 ton-hours unless free storage devices are available.

c. For a larger system (storage capacity over 2000 ton-hours), a chilled water storage system is recommended. Modular ice systems for a large cooling plant require extensive piping and flow balancing. This increases the system first cost as well as future system maintenance costs. Note that the size of the cool storage is given in terms of ton-hours. The cooling capacity of the cool storage in terms of tons depends on the discharge period (i.e., the shift window). As an example, a 2000 ton-hr cool storage system will provide 500 tons of cooling for a discharge period of 4 hours (shift window of 4 hours, such as from 1200 to 1600 hours) or 250 tons of cooling for a discharge period of 8 hours (such as from 0900 to 1700 hours).

Table A-5. Comparison of Ice and Chilled Water as Storage Media

Characteristic	Ice	Water
Volume	Compact	Large
System	Modular	Becoming modular
Economy of scale	Low	High
Compressor derating	Severe (30%)	None
Energy penalty	High (up to 30%)	None
Blending control	Simple	Being Established

d. Ice systems can deliver lower temperature air than conventional or chilled water storage systems. The concept has a number of merits including reduced hardware size, pumping, and fan power. The operation and maintenance of such systems, however, has yet to be proven through field validations. The low temperature air systems are not recommended for Army applications until their performance is fully established. In retrofit applications, however, where cooling loads have outgrown the delivery capacity of the existing system, a low temperature air system may be used to supplement the capacity without major changes in piping and ducting.

e. Regardless of the type of storage medium, retrofit applications are the least cost effective. The payback of a storage cooling system for new construction or replacement is two to three times quicker than for a retrofit application.

APPENDIX 4E

TRANE TRACE OUTPUT

24 HOUR LOAD PROFILES

BUILDING COOL-HEAT DEMAND - ALTERNATIVE 1
BASELINE MODEL

January			Design		Weekday		Saturday		Sunday		Monday	
Hour	OADB	OAWB	Htg Btuh	Clg Ton	Htg Btuh	Clg Ton	Htg Btuh	Clg Ton	Htg Btuh	Clg Ton	Htg Btuh	Clg Ton
1	42.6	39.9	-1,429,445	50.6	-1,976,341	47.3	-1,981,861	47.4	-2,011,151	47.4	-1,978,873	47.4
2	41.4	38.7	-1,795,620	48.5	-2,146,285	46.4	-2,133,486	46.5	-2,133,419	46.5	-2,153,592	46.5
3	40.7	38.1	-1,575,065	47.3	-2,147,770	45.3	-2,156,432	45.4	-2,130,530	45.4	-2,123,153	45.4
4	40.4	37.8	-1,882,677	46.1	-2,213,713	44.1	-2,202,781	44.2	-2,230,458	44.2	-2,245,730	44.2
5	40.8	38.1	-1,660,262	44.7	-2,176,526	42.8	-2,184,812	42.9	-2,169,349	42.8	-2,157,982	42.8
6	41.8	39.1	-1,862,672	44.5	-2,141,921	43.0	-2,152,871	41.8	-2,160,926	41.8	-2,141,944	43.0
7	43.4	40.7	-1,324,200	59.0	-1,697,081	55.9	-2,023,023	40.6	-2,012,229	40.6	-1,702,463	55.9
8	45.4	42.8	-1,098,025	83.2	-1,339,991	77.1	-1,858,296	40.7	-1,871,155	40.7	-1,338,981	77.1
9	47.7	44.9	-863,272	87.1	-1,019,007	79.7	-1,339,608	56.6	-1,453,681	52.6	-1,010,047	79.6
10	50.2	46.6	-643,544	90.7	-1,108,813	82.7	-1,227,317	57.0	-1,322,712	52.7	-1,108,813	82.7
11	52.5	47.9	-511,804	98.6	-660,508	87.0	-1,085,423	58.2	-1,030,194	53.7	-671,611	86.9
12	54.5	49.3	-313,768	108.2	-761,749	91.6	-871,123	60.4	-964,468	55.6	-752,074	91.6
13	56.1	50.5	-230,781	117.5	-446,388	97.7	-752,032	64.9	-764,567	59.6	-446,388	97.7
14	57.1	51.1	-138,691	127.7	-530,652	103.7	-785,571	46.4	-814,895	46.2	-530,652	103.1
15	57.5	50.8	-117,358	135.8	-469,520	107.6	-817,667	49.4	-788,690	49.3	-479,918	107.6
16	57.2	50.4	-130,609	136.9	-591,703	109.2	-845,332	51.7	-878,450	51.7	-580,273	109.2
17	56.5	49.9	-300,113	131.4	-500,704	106.8	-902,457	52.1	-843,875	52.1	-510,195	106.8
18	55.3	49.7	-371,579	122.0	-764,735	102.1	-1,093,856	50.6	-1,098,878	50.6	-752,051	102.1
19	53.8	49.3	-716,354	90.3	-1,027,900	71.2	-1,129,154	49.7	-1,153,087	49.7	-1,042,312	71.2
20	52.0	48.2	-975,013	62.1	-1,293,410	51.4	-1,348,311	50.1	-1,345,607	50.1	-1,278,956	51.4
21	50.0	46.6	-1,119,588	58.2	-1,435,830	51.3	-1,414,016	50.2	-1,419,191	50.2	-1,450,050	51.3
22	47.9	44.8	-1,284,863	55.4	-1,605,938	49.9	-1,646,187	50.1	-1,638,922	50.1	-1,592,112	49.9
23	45.9	43.0	-1,358,481	53.5	-1,755,193	49.6	-1,720,964	49.8	-1,715,631	49.8	-1,768,577	49.6
24	44.1	41.2	-1,557,509	50.8	-1,926,527	48.2	-1,868,064	49.2	-1,895,886	49.3	-1,913,351	48.2

February			Design		Weekday		Saturday		Sunday		Monday	
Hour	OADB	OAWB	Htg Btuh	Clg Ton	Htg Btuh	Clg Ton	Htg Btuh	Clg Ton	Htg Btuh	Clg Ton	Htg Btuh	Clg Ton
1	45.0	41.6	-1,640,022	51.9	-1,742,617	46.8	-1,864,379	47.0	-1,775,736	47.0	-1,869,275	46.9
2	43.3	40.3	-1,762,636	50.2	-2,098,749	46.3	-1,994,058	46.4	-2,065,266	46.4	-1,996,087	46.4
3	41.8	39.1	-1,804,280	48.4	-1,974,738	46.0	-2,070,580	46.1	-2,003,840	46.1	-2,072,622	46.1
4	40.5	38.0	-1,842,258	47.2	-2,303,886	45.1	-2,192,654	45.2	-2,270,748	45.2	-2,194,733	45.1
5	39.6	37.1	-1,898,307	45.9	-2,122,335	44.0	-2,246,653	44.1	-2,151,763	44.1	-2,248,794	44.1
6	39.0	36.8	-1,855,353	45.7	-2,395,731	44.1	-2,300,931	43.0	-2,387,178	43.0	-2,267,415	44.2
7	38.8	36.6	-1,513,445	59.1	-1,898,127	55.7	-2,305,876	42.4	-2,235,280	42.4	-2,017,981	55.7
8	39.4	37.2	-1,110,659	83.1	-1,554,302	74.0	-2,147,933	43.3	-2,202,949	43.3	-1,485,549	74.0
9	40.9	38.1	-927,999	86.5	-1,522,581	76.0	-1,803,387	57.0	-1,930,553	53.6	-1,493,293	76.0
10	43.3	39.3	-713,117	85.8	-1,358,988	78.6	-1,650,019	58.2	-1,686,618	54.5	-1,358,845	78.6
11	46.2	40.8	-559,388	97.1	-1,021,492	81.9	-1,424,697	59.7	-1,433,451	55.6	-1,117,882	81.9
12	49.3	42.7	-340,231	107.9	-991,946	86.8	-1,358,209	62.2	-1,335,490	57.7	-991,946	86.8
13	52.2	44.9	-266,875	118.1	-746,812	91.3	-891,964	63.9	-1,091,926	59.2	-692,062	91.3
14	54.5	46.8	-167,736	128.3	-646,502	96.4	-1,067,300	46.0	-964,602	45.9	-646,502	96.4
15	56.1	47.8	-138,805	136.6	-482,612	102.4	-766,930	49.0	-868,030	48.9	-482,612	102.4
16	56.6	48.0	-154,768	139.6	-536,091	105.7	-958,524	51.2	-807,691	51.2	-592,642	105.7
17	56.4	47.7	-244,361	135.1	-575,240	105.4	-761,728	52.1	-949,923	52.1	-496,235	105.4
18	55.9	47.7	-393,191	124.9	-713,084	101.4	-1,192,027	50.0	-1,020,674	50.0	-787,752	101.4
19	54.9	48.6	-636,028	93.9	-996,663	71.7	-984,861	50.1	-1,107,888	50.1	-907,370	71.7
20	53.7	48.5	-1,140,169	68.6	-1,159,962	49.9	-1,299,777	48.6	-1,194,007	48.6	-1,251,774	49.9
21	52.2	47.8	-1,069,688	61.9	-1,303,052	49.8	-1,196,812	48.7	-1,303,925	48.7	-1,211,415	49.8
22	50.5	46.7	-1,489,186	58.7	-1,430,684	48.5	-1,550,266	48.8	-1,443,457	48.8	-1,520,285	48.5
23	48.7	44.9	-1,339,654	56.5	-1,582,404	48.5	-1,446,465	48.7	-1,553,419	48.7	-1,494,278	48.5
24	46.8	43.3	-1,734,560	53.2	-1,736,011	47.2	-1,809,154	48.5	-1,703,500	48.5	-1,822,838	47.2

BUILDING COOL-HEAT DEMAND - ALTERNATIVE 1
BASELINE MODEL

March			------ Design -----		----- Weekday -----		----- Saturday----		------ Sunday -----		------ Monday -----	
Hour	OADB	OAWB	Htg Btuh	Clg Ton	Htg Btuh	Clg Ton	Htg Btuh	Clg Ton	Htg Btuh	Clg Ton	Htg Btuh	Clg Ton
1	55.3	52.2	-760,624	60.0	-1,093,472	52.5	-1,058,574	54.7	-1,071,687	54.5	-1,060,037	54.4
2	53.5	50.4	-1,053,787	56.7	-1,187,324	49.7	-1,227,480	50.5	-1,214,438	50.5	-1,229,125	50.4
3	52.0	49.2	-903,076	54.3	-1,361,270	49.6	-1,313,882	50.1	-1,326,767	50.1	-1,315,553	50.0
4	50.7	48.0	-1,171,311	51.8	-1,401,637	49.1	-1,448,976	49.5	-1,436,135	49.5	-1,450,752	49.4
5	49.8	46.9	-980,608	50.1	-1,537,838	48.2	-1,484,383	48.4	-1,497,123	48.4	-1,486,108	48.4
6	49.2	46.4	-1,145,699	49.2	-1,516,176	48.7	-1,586,139	47.3	-1,573,963	47.3	-1,567,704	48.7
7	49.0	46.4	-682,375	69.8	-1,307,886	64.8	-1,535,962	46.8	-1,546,728	46.8	-1,260,690	64.8
8	49.8	46.7	-546,033	104.2	-813,273	89.7	-1,371,981	47.8	-1,371,981	47.8	-827,460	89.8
9	52.0	47.8	-265,094	112.6	-933,968	93.2	-959,735	65.2	-1,132,964	60.7	-952,829	93.3
10	55.3	49.6	-136,422	124.0	-517,925	98.7	-948,740	66.8	-787,376	61.7	-517,925	98.7
11	59.2	52.1	-43,140	147.0	-455,192	107.7	-481,421	71.4	-670,547	65.1	-446,453	108.3
12	63.1	54.5	-7,526	171.6	-143,608	118.2	-318,776	75.0	-266,848	67.6	-143,608	118.5
13	66.4	56.9	-2,585	193.1	-116,607	137.5	-150,217	88.2	-187,535	77.4	-116,607	137.5
14	68.6	58.5	-3,426	208.7	-28,799	155.4	-55,699	69.2	-47,332	68.1	-37,166	155.5
15	69.4	58.7	-3,084	218.6	-20,458	165.1	-26,509	76.7	-26,509	75.9	-20,458	165.1
16	69.2	58.6	-4,391	220.2	-112,348	166.3	-112,864	78.4	-122,849	78.0	-102,362	166.3
17	68.6	58.8	-5,175	212.7	-113,968	162.2	-142,886	77.7	-132,687	77.5	-124,166	162.2
18	67.7	58.7	-7,069	193.6	-134,503	161.3	-156,071	76.9	-167,412	76.6	-123,162	161.3
19	66.4	59.0	-104,855	137.5	-197,626	114.0	-269,868	72.3	-256,279	72.1	-211,215	114.0
20	64.9	59.3	-233,248	97.8	-359,952	79.4	-304,443	74.0	-318,793	73.9	-345,602	79.4
21	63.1	58.5	-384,107	86.7	-429,944	69.5	-494,986	67.3	-480,735	67.3	-444,195	69.5
22	61.2	57.2	-513,050	76.7	-639,382	64.8	-597,493	65.3	-611,457	65.3	-625,418	64.8
23	59.2	55.4	-664,117	71.6	-754,290	64.1	-772,268	64.7	-758,535	64.7	-768,023	64.1
24	57.2	53.9	-758,692	64.8	-947,640	57.0	-907,201	59.2	-920,572	59.2	-934,269	57.0

April			------ Design -----		----- Weekday -----		----- Saturday----		------ Sunday -----		------ Monday -----	
Hour	OADB	OAWB	Htg Btuh	Clg Ton	Htg Btuh	Clg Ton	Htg Btuh	Clg Ton	Htg Btuh	Clg Ton	Htg Btuh	Clg Ton
1	63.1	60.6	-168,426	87.2	-476,514	82.3	-586,483	81.4	-538,280	81.4	-587,215	81.2
2	62.0	59.6	-218,879	81.4	-545,654	75.3	-464,136	73.9	-512,403	73.8	-465,159	73.7
3	61.1	58.8	-222,128	76.6	-665,815	70.6	-728,196	69.7	-679,417	69.7	-729,342	69.5
4	60.5	58.3	-274,325	71.6	-661,433	66.8	-606,839	67.4	-655,271	67.4	-608,077	67.3
5	60.4	58.4	-247,713	71.4	-677,789	67.6	-771,748	65.0	-725,917	65.0	-727,430	67.8
6	60.9	58.7	-229,818	102.9	-497,916	95.1	-585,355	62.1	-627,783	62.1	-443,719	95.2
7	62.3	60.1	-37,803	160.6	-372,924	153.2	-497,810	70.7	-522,116	70.7	-348,618	152.7
8	64.6	61.8	-133,007	186.2	-109,986	166.0	-219,188	108.0	-186,645	98.4	-171,371	165.8
9	67.3	63.2	-1,152	205.4	-47,846	179.5	-124,600	119.0	-124,793	106.2	-72,856	179.5
10	70.3	64.3	0	213.1	-98,731	214.3	-100,353	149.6	-100,809	134.0	-98,731	214.3
11	73.0	65.3	0	244.5	-25,675	238.7	0	175.9	-25,675	159.5	0	238.7
12	75.2	66.1	0	266.1	0	255.6	0	194.6	0	178.3	0	255.6
13	76.7	66.6	0	283.6	0	268.5	0	165.3	0	163.4	0	268.5
14	77.2	66.9	0	298.9	0	277.3	0	175.2	0	174.6	0	277.3
15	77.0	66.4	0	307.9	0	278.7	0	177.6	0	177.4	0	278.7
16	76.5	66.2	0	307.0	0	274.0	0	176.8	0	176.7	0	274.0
17	75.6	65.8	0	299.6	-158,996	252.9	-126,897	161.8	-157,072	161.8	-126,897	252.9
18	74.4	66.0	0	245.6	-32,510	207.2	-77,287	160.3	-32,510	160.3	-77,287	207.2
19	73.0	66.1	0	197.1	-182,770	160.5	-141,599	149.1	-182,770	149.1	-141,599	160.5
20	71.4	66.3	0	184.1	-33,714	150.4	-80,199	142.5	-33,714	142.5	-80,199	150.4
21	69.7	65.6	-123,097	156.0	-241,834	128.9	-192,696	129.7	-241,834	129.7	-192,696	128.9
22	67.9	64.6	-91,001	135.9	-107,872	110.6	-157,090	112.6	-107,184	112.6	-157,778	110.6
23	66.2	63.4	-174,656	117.8	-391,665	97.6	-334,207	103.0	-383,135	103.0	-342,737	97.6
24	64.6	62.0	-111,436	107.8	-245,347	86.8	-292,731	86.9	-244,752	86.9	-293,326	86.8

BUILDING COOL-HEAT DEMAND - ALTERNATIVE 1
BASELINE MODEL

May			Design		Weekday		Saturday		Sunday		Monday	
Hour	OADB	OAWB	Htg Btuh	Clg Ton	Htg Btuh	Clg Ton	Htg Btuh	Clg Ton	Htg Btuh	Clg Ton	Htg Btuh	Clg Ton
1	67.4	66.0	-180,838	152.9	-159,586	114.1	-279,642	112.5	-279,512	111.9	-279,931	111.7
2	66.4	64.6	-155,307	146.0	-372,220	104.1	-237,310	99.3	-237,277	99.6	-237,735	99.4
3	65.6	63.5	-42,451	125.8	-225,200	97.3	-369,259	94.1	-369,259	94.2	-370,047	94.0
4	65.0	62.4	-221,696	116.1	-450,305	95.3	-295,726	92.3	-295,726	92.3	-299,659	92.2
5	64.8	62.3	-43,135	115.5	-258,639	96.6	-421,086	89.7	-421,086	89.7	-408,982	93.3
6	65.2	62.1	-197,028	167.3	-291,985	136.8	-225,718	90.0	-225,718	90.0	-160,134	136.0
7	66.2	62.4	0	242.5	-167,555	204.6	-248,098	101.2	-248,098	101.2	-181,930	205.4
8	68.0	62.5	-118,619	248.5	-19,204	206.1	-63,735	145.4	-70,870	131.6	-27,670	206.3
9	70.6	63.4	0	268.0	-29,645	228.4	-30,630	164.7	-30,906	148.7	-29,645	228.4
10	73.7	64.2	0	293.5	-87,747	254.0	-87,747	192.0	-87,747	175.6	-87,747	253.9
11	77.1	65.5	-88,672	323.1	0	282.3	0	221.6	0	205.0	0	282.2
12	80.3	67.0	0	354.2	0	323.1	0	261.3	0	243.9	0	323.1
13	82.8	68.7	0	397.7	-85,988	346.9	-85,988	241.2	-85,988	239.3	-85,988	346.9
14	84.4	69.4	-93,975	420.5	0	364.9	0	261.1	0	260.6	0	364.8
15	85.0	69.4	0	432.1	-88,192	373.5	-88,192	270.9	-88,192	270.8	-88,192	373.4
16	84.4	69.7	-107,389	428.8	0	380.0	0	278.9	0	278.9	0	380.0
17	83.0	70.0	-79,036	416.5	-126,270	364.7	-126,270	267.9	-126,270	267.9	-126,270	364.6
18	80.7	70.5	-87,259	351.3	-29,318	300.5	-29,318	253.5	-29,318	253.5	-29,318	300.5
19	78.1	71.0	-95,676	291.9	-218,002	235.3	-228,670	222.8	-228,670	222.8	-228,670	235.3
20	75.5	71.9	-101,030	272.0	-106,824	213.1	-106,824	203.8	-106,824	203.8	-106,824	213.1
21	73.3	71.8	-99,040	247.4	-85,994	192.8	-85,994	190.4	-85,994	190.4	-85,994	192.8
22	71.2	70.4	-192,060	212.5	-166,528	162.0	-166,528	160.3	-166,528	160.3	-166,528	162.0
23	69.6	69.0	-88,543	188.7	-106,117	133.7	-106,117	137.2	-106,117	137.2	-106,117	133.7
24	68.4	67.5	-198,198	175.2	-217,687	124.8	-218,202	122.9	-218,202	122.9	-217,687	124.8

June			Design		Weekday		Saturday		Sunday		Monday	
Hour	OADB	OAWB	Htg Btuh	Clg Ton	Htg Btuh	Clg Ton	Htg Btuh	Clg Ton	Htg Btuh	Clg Ton	Htg Btuh	Clg Ton
1	73.1	70.5	-194,572	227.6	-79,047	184.3	-168,426	187.0	-79,047	184.1	-168,426	183.7
2	72.2	69.6	-128,790	219.3	-123,389	173.7	-32,484	171.7	-123,390	169.6	-32,484	169.3
3	71.5	68.6	-181,120	207.6	-140,272	163.3	-232,245	162.3	-140,272	159.8	-232,245	158.6
4	71.0	68.2	-125,692	199.4	-129,941	148.7	-36,003	147.0	-129,941	144.6	-36,003	145.4
5	70.8	68.0	-174,428	199.4	-143,940	147.0	-236,345	141.0	-144,014	139.1	-236,270	144.5
6	71.1	68.1	-117,672	249.2	-108,441	202.1	-31,651	141.4	-108,441	142.1	-31,651	201.5
7	72.0	68.6	0	321.1	-113,105	294.4	-113,105	170.6	-113,105	170.9	-113,105	294.9
8	73.7	69.1	-129,113	336.5	0	293.8	0	231.1	0	214.5	0	293.5
9	76.0	70.7	0	343.7	-79,598	319.9	-79,598	253.2	-79,598	235.5	-79,598	319.5
10	78.7	72.9	-100,527	383.2	0	348.0	0	281.7	0	263.5	0	347.6
11	81.7	74.6	0	414.1	0	371.7	0	307.5	0	289.3	0	371.3
12	84.6	75.3	-89,060	444.3	-106,782	401.7	-106,782	338.4	-106,782	320.1	-106,782	401.3
13	86.7	75.7	0	487.7	0	450.3	0	334.7	0	333.1	0	450.0
14	88.2	75.7	-85,853	508.8	-92,234	485.2	-92,234	371.5	-92,234	371.2	-92,234	484.9
15	88.7	76.2	0	537.7	0	505.4	0	392.0	0	391.9	0	505.1
16	88.2	75.2	-115,375	535.5	-126,095	481.9	-126,095	375.7	-126,095	375.7	-126,095	481.6
17	86.9	74.7	-87,287	506.7	-84,623	466.3	-84,623	363.0	-84,623	363.1	-84,623	466.0
18	84.9	74.3	-99,266	439.8	-115,558	387.3	-115,558	338.7	-115,558	338.7	-115,558	387.0
19	82.6	74.4	-109,051	378.3	-91,532	333.0	-91,532	318.9	-91,532	318.9	-91,532	332.7
20	80.3	74.8	-116,793	345.7	-119,953	300.0	-188,157	290.4	-119,953	290.3	-188,157	299.7
21	78.3	74.4	-115,960	319.7	-188,147	270.2	-92,314	266.5	-188,147	266.5	-92,314	269.9
22	76.5	73.5	-137,536	296.4	-117,698	247.3	-199,703	245.5	-117,698	245.5	-199,703	247.0
23	75.1	72.7	-108,376	273.1	-167,998	226.5	-83,710	230.5	-167,998	230.5	-83,710	226.3
24	74.0	71.3	-224,530	247.9	-113,142	206.6	-200,033	202.8	-113,142	202.8	-200,033	206.4

BUILDING COOL-HEAT DEMAND - ALTERNATIVE 1
BASELINE MODEL

July			------ Design -----		----- Weekday -----		----- Saturday----		------ Sunday -----		------ Monday -----	
Hour	OADB	OAWB	Htg Btuh	Clg Ton	Htg Btuh	Clg Ton	Htg Btuh	Clg Ton	Htg Btuh	Clg Ton	Htg Btuh	Clg Ton
1	74.0	72.9	-106,743	254.9	-156,345	206.7	-82,076	209.7	-82,076	207.4	-82,076	207.0
2	73.2	71.6	-215,081	238.8	-123,985	192.6	-203,113	191.0	-203,113	189.0	-203,113	188.6
3	72.6	70.7	-102,407	229.2	-157,550	183.7	-77,740	181.8	-77,740	179.5	-77,740	179.1
4	72.1	70.0	-216,581	221.5	-46,108	165.8	-126,911	167.0	-126,911	164.6	-126,911	162.9
5	72.0	69.6	-96,962	222.0	-217,377	167.8	-138,588	157.9	-138,588	157.2	-138,588	165.4
6	72.3	69.4	-195,340	269.6	-42,424	223.1	-113,579	161.8	-113,579	162.4	-113,579	222.6
7	73.1	70.0	-81,014	344.4	-117,703	320.3	-117,703	192.1	-117,703	192.3	-117,703	320.9
8	74.5	70.0	0	357.7	0	321.3	0	256.5	0	238.7	0	321.0
9	76.5	70.7	-122,890	378.6	-87,643	339.3	-87,643	270.8	-87,643	252.5	-87,643	339.0
10	78.8	71.5	0	401.4	0	360.8	0	293.6	0	275.0	0	360.5
11	81.4	73.0	-95,103	428.0	0	400.6	0	332.9	0	313.8	0	400.3
12	83.9	74.3	0	473.6	-106,814	442.4	-106,814	374.9	-106,814	355.3	-106,814	442.1
13	85.8	76.1	-87,552	516.2	0	481.7	0	359.7	0	358.4	0	481.5
14	87.0	77.3	0	537.3	-89,307	498.7	-89,307	382.5	-89,307	382.2	-89,307	498.4
15	87.5	77.9	-95,631	560.6	0	519.9	0	402.5	0	402.5	0	519.6
16	87.0	77.9	0	546.8	-121,812	510.8	-121,812	398.8	-121,812	398.8	-121,812	510.6
17	85.9	78.1	-144,717	534.4	-81,245	495.4	-81,245	387.8	-81,245	387.8	-81,245	495.1
18	84.2	77.6	-98,838	467.6	-113,598	411.2	-113,598	362.0	-113,598	362.0	-113,598	411.0
19	82.2	77.7	-108,306	390.6	-90,788	343.0	-90,788	330.1	-90,788	330.1	-90,788	342.8
20	80.2	78.0	-117,475	372.5	-204,453	323.1	-195,275	313.4	-195,275	313.4	-195,275	322.9
21	78.5	77.5	-117,849	335.7	-93,182	293.7	-93,182	290.7	-93,182	290.7	-93,182	293.4
22	76.9	76.6	-137,029	311.2	-203,861	264.6	-203,861	263.0	-203,861	263.0	-203,861	264.3
23	75.7	75.3	-169,545	290.3	-86,553	234.7	-86,553	239.0	-86,553	239.0	-86,553	234.4
24	74.8	74.1	-147,237	264.7	-202,765	225.7	-202,765	221.7	-202,765	221.7	-202,765	225.4

August			------ Design ------		----- Weekday -----		----- Saturday----		------ Sunday -----		------ Monday -----	
Hour	OADB	OAWB	Htg Btuh	Clg Ton	Htg Btuh	Clg Ton	Htg Btuh	Clg Ton	Htg Btuh	Clg Ton	Htg Btuh	Clg Ton
1	74.4	72.7	-107,361	258.6	-122,810	212.6	-204,160	214.8	-204,160	212.8	-204,160	212.4
2	73.5	71.6	-212,744	239.9	-160,532	197.5	-80,919	195.9	-80,919	194.0	-80,919	193.6
3	72.9	70.9	-102,531	231.3	-122,959	187.4	-203,169	185.7	-203,169	183.3	-203,169	183.0
4	72.4	70.2	-215,396	223.2	-158,762	176.7	-77,616	178.9	-77,616	176.5	-77,616	174.6
5	72.2	69.6	-96,867	212.7	-43,779	173.8	-122,389	164.9	-122,389	164.2	-122,389	171.4
6	72.5	69.6	-199,631	267.4	-205,758	226.6	-132,821	164.5	-132,821	165.2	-132,821	226.1
7	73.4	70.3	-84,366	344.7	-23,092	321.7	-23,092	193.7	-23,092	193.8	-23,092	322.2
8	74.9	71.2	-77,963	358.1	-106,189	332.5	-106,189	265.4	-106,189	247.1	-106,189	332.2
9	77.0	72.0	0	379.1	0	351.0	0	281.3	0	262.7	0	350.6
10	79.5	73.5	-118,598	403.8	-88,929	368.2	-88,929	300.8	-88,929	282.2	-88,929	367.8
11	82.4	74.9	0	433.7	0	407.8	0	340.1	0	321.0	0	407.4
12	85.0	76.5	-101,182	479.0	-87,225	451.2	-87,225	383.9	-87,225	364.3	-87,225	450.9
13	87.1	76.9	0	505.7	0	478.4	0	359.1	0	357.8	0	478.1
14	88.4	77.5	-92,449	541.9	-97,625	502.8	-97,625	387.1	-97,625	386.9	-97,625	502.5
15	88.9	78.0	0	553.9	0	530.2	0	412.9	0	412.8	0	529.9
16	88.4	78.2	-120,657	564.7	-130,625	525.7	-130,625	413.9	-130,625	413.9	-130,625	525.4
17	87.2	78.6	-93,778	556.9	-88,130	523.9	-88,130	412.4	-88,130	412.4	-88,130	523.6
18	85.4	78.1	-107,462	471.9	-93,007	427.5	-93,007	378.5	-93,007	378.5	-93,007	427.2
19	83.2	78.3	-117,960	407.2	-193,368	368.2	-204,066	354.6	-204,066	354.6	-204,066	368.0
20	81.0	78.5	-122,330	375.7	-99,705	336.3	-99,705	326.8	-99,705	326.8	-99,705	336.1
21	79.2	77.6	-120,058	352.4	-204,639	305.7	-204,639	303.2	-204,639	303.2	-204,639	305.5
22	77.5	76.2	-170,967	314.1	-91,840	274.8	-91,840	273.3	-91,840	273.3	-91,840	274.6
23	76.2	75.0	-148,799	291.5	-202,631	242.9	-202,631	247.5	-202,631	247.5	-202,631	242.7
24	75.2	73.9	-180,333	278.7	-86,512	232.5	-86,512	228.5	-86,512	228.5	-86,512	232.3

BUILDING COOL-HEAT DEMAND - ALTERNATIVE 1
BASELINE MODEL

September			------ Design -----		----- Weekday -----		----- Saturday----		------ Sunday -----		------ Monday -----	
Hour	OADB	OAWB	Htg Btuh	Clg Ton	Htg Btuh	Clg Ton	Htg Btuh	Clg Ton	Htg Btuh	Clg Ton	Htg Btuh	Clg Ton
1	71.2	70.1	-212,764	204.1	0	143.7	-126,242	143.3	-96,140	143.9	-126,242	143.6
2	70.3	68.7	-93,908	185.5	-277,854	131.4	-148,150	129.0	-179,663	129.2	-148,150	128.7
3	69.6	67.5	-207,366	176.5	-14,375	124.1	-147,660	122.1	-114,745	122.2	-147,660	121.8
4	69.1	66.7	-89,264	168.2	-310,679	121.5	-172,512	118.9	-206,500	118.9	-173,135	118.7
5	68.9	66.0	-200,507	166.9	-31,850	118.0	-174,286	110.7	-140,842	110.7	-166,157	115.5
6	69.2	65.4	-85,042	212.6	-278,963	164.5	-164,056	110.6	-196,141	110.6	-153,111	164.8
7	70.1	65.6	0	282.7	-6,579	247.9	-102,954	127.7	-77,433	127.7	-99,479	248.5
8	71.7	65.4	-164,958	296.9	-98,898	266.9	-98,898	199.5	-98,898	182.5	-98,898	266.9
9	74.0	65.5	0	318.2	-33,216	278.0	0	211.8	-24,504	194.7	0	278.0
10	76.7	66.1	-109,067	342.4	-85,159	299.7	-85,159	234.9	-85,159	217.5	-85,159	299.7
11	79.7	67.7	0	372.4	0	339.1	0	273.4	0	255.3	0	339.1
12	82.5	69.9	-93,340	401.6	-90,721	362.0	-90,721	298.0	-90,721	280.0	-90,721	362.0
13	84.6	71.5	0	443.5	0	394.3	0	280.9	0	279.2	0	394.3
14	86.1	72.9	-99,472	464.7	-104,762	424.2	-104,762	311.2	-104,762	310.8	-104,762	424.2
15	86.6	73.3	0	474.6	0	429.7	0	318.9	0	318.8	0	429.7
16	86.1	73.0	-138,803	470.8	-136,315	421.1	-136,315	315.8	-136,315	315.8	-136,315	421.1
17	84.8	73.3	-98,741	457.2	-166,007	402.8	-160,862	301.6	-160,862	301.6	-160,862	402.8
18	82.9	74.8	-110,263	399.7	-93,766	345.3	-123,706	295.4	-93,766	295.4	-123,706	345.3
19	80.6	76.2	-118,124	341.9	-209,538	290.8	-175,813	279.9	-209,538	279.9	-175,813	290.8
20	78.3	76.1	-199,116	312.7	-92,127	260.6	-118,239	252.0	-92,127	252.0	-118,239	260.6
21	76.3	75.4	-110,956	288.8	-202,364	230.3	-175,888	229.6	-202,364	229.6	-175,888	230.3
22	74.6	74.3	-189,096	253.4	-81,259	204.0	-108,179	202.9	-81,259	202.9	-108,179	204.0
23	73.1	73.1	-101,495	232.8	-120,216	180.8	-92,220	186.8	-120,216	186.8	-92,220	180.8
24	72.1	71.6	-217,107	209.6	-138,555	162.8	-167,669	161.2	-138,555	161.2	-167,669	162.8

October			------ Design ------		----- Weekday -----		----- Saturday----		------ Sunday -----		------ Monday ------	
Hour	OADB	OAWB	Htg Btuh	Clg Ton	Htg Btuh	Clg Ton	Htg Btuh	Clg Ton	Htg Btuh	Clg Ton	Htg Btuh	Clg Ton
1	58.4	55.8	-533,725	68.8	-725,340	58.3	-889,827	62.6	-731,072	62.6	-891,073	62.5
2	56.7	53.9	-727,549	60.0	-1,093,392	54.3	-927,413	55.8	-1,083,551	55.8	-928,832	55.7
3	55.3	52.7	-713,217	55.8	-964,644	52.2	-1,131,420	53.0	-977,890	53.0	-1,132,988	52.9
4	54.1	51.8	-849,679	52.8	-1,287,338	49.6	-1,116,557	50.0	-1,268,842	50.0	-1,118,109	49.9
5	53.2	51.0	-745,691	52.6	-1,099,549	49.7	-1,298,308	48.1	-1,152,156	48.1	-1,263,580	49.8
6	52.6	50.4	-671,341	73.8	-1,146,838	68.0	-1,232,914	47.5	-1,369,517	47.5	-994,260	68.1
7	52.4	50.4	-411,378	105.1	-748,266	94.9	-1,287,104	48.3	-1,195,049	48.3	-840,321	95.0
8	53.5	51.1	-317,289	117.3	-678,633	98.7	-834,033	67.6	-932,360	62.6	-705,645	98.7
9	56.5	52.9	-115,391	130.4	-621,616	107.3	-801,867	71.8	-878,015	65.4	-519,811	107.3
10	60.8	54.3	-36,467	147.4	-394,658	118.1	-544,940	75.2	-536,590	67.5	-449,902	118.0
11	65.7	57.3	-2,036	171.8	-91,898	134.1	-181,423	82.9	-178,995	73.2	-101,887	133.8
12	70.0	60.0	0	202.1	-15,353	168.9	-17,528	111.8	-18,138	97.3	-15,353	168.9
13	73.0	62.0	0	222.8	0	192.8	0	99.1	0	97.2	0	192.8
14	74.1	62.2	0	238.1	-9,546	203.2	0	109.8	-9,546	108.9	0	203.2
15	73.9	62.2	0	246.6	-87,696	206.0	0	113.3	-87,696	112.8	0	206.0
16	73.3	61.8	0	243.5	-68,261	201.6	-206,072	112.1	-68,261	111.8	-206,072	201.6
17	72.4	61.7	0	232.5	-123,855	192.8	0	105.8	-123,855	105.7	0	192.8
18	71.2	62.8	-157,004	183.7	-84,669	146.6	-232,030	100.8	-84,669	100.7	-232,030	146.6
19	69.8	64.0	0	137.2	-186,414	107.7	-20,712	99.6	-186,414	99.6	-20,712	107.7
20	68.1	63.7	-234,934	113.3	-156,982	104.1	-323,909	101.3	-153,211	101.3	-327,680	104.1
21	66.2	62.5	-98,354	94.3	-337,801	87.3	-170,225	88.6	-339,424	88.6	-168,602	87.3
22	64.2	60.9	-407,921	78.5	-334,056	82.2	-497,318	83.3	-331,103	83.3	-500,270	82.2
23	62.3	59.2	-267,449	68.3	-594,104	71.4	-413,746	75.1	-576,129	75.1	-431,721	71.4
24	60.3	57.4	-632,436	61.3	-654,512	64.9	-813,820	65.0	-653,310	65.0	-815,022	64.9

BUILDING COOL-HEAT DEMAND - ALTERNATIVE 1
BASELINE MODEL

November			------ Design -----		----- Weekday -----		----- Saturday----		------ Sunday -----		------ Monday -----	
Hour	OADB	OAWB	Htg Btuh	Clg Ton	Htg Btuh	Clg Ton	Htg Btuh	Clg Ton	Htg Btuh	Clg Ton	Htg Btuh	Clg Ton
1	56.4	54.8	-665,778	55.8	-1,145,732	53.2	-885,015	57.6	-914,067	57.7	-886,415	57.6
2	54.7	53.1	-975,526	53.1	-998,770	50.2	-1,254,004	51.9	-1,224,656	51.9	-1,255,601	51.8
3	53.3	51.8	-809,399	51.1	-1,382,354	48.5	-1,119,905	49.4	-1,149,485	49.4	-1,121,500	49.3
4	52.1	50.4	-1,082,277	48.3	-1,203,266	47.3	-1,465,509	47.7	-1,435,623	47.7	-1,467,236	47.6
5	51.2	49.7	-884,326	47.2	-1,556,191	47.1	-1,301,356	47.3	-1,331,595	47.3	-1,303,071	47.2
6	50.6	49.1	-1,045,431	46.9	-1,302,959	47.6	-1,566,760	46.1	-1,537,813	46.1	-1,535,198	47.7
7	50.5	49.0	-608,384	67.0	-1,357,620	64.4	-1,367,545	45.2	-1,394,972	45.2	-1,141,566	64.5
8	51.2	49.7	-568,120	104.9	-750,442	91.0	-1,423,079	46.0	-1,423,079	46.0	-876,922	91.0
9	53.3	50.9	-240,459	114.0	-775,424	95.5	-863,389	64.7	-962,708	59.8	-802,670	95.6
10	56.4	52.3	-108,726	125.7	-559,992	101.6	-822,871	67.7	-738,063	61.7	-486,390	101.6
11	60.0	54.1	-34,182	145.8	-455,328	113.0	-453,813	72.3	-587,357	65.0	-386,952	111.9
12	63.7	56.5	-1,920	173.7	-153,199	124.5	-411,545	76.8	-398,601	68.4	-263,446	124.5
13	66.8	58.1	0	194.3	-55,882	140.0	-89,183	88.4	-121,060	77.2	-55,882	140.0
14	68.9	59.6	0	208.5	-26,130	164.5	-50,765	72.1	-50,765	70.4	-36,072	164.5
15	69.6	60.0	0	216.0	-106,969	175.1	-24,177	80.3	-24,177	79.3	-18,792	175.1
16	69.4	60.2	-8,482	214.2	-87,318	174.3	-161,201	80.3	-161,201	79.8	-155,149	174.3
17	68.9	60.4	-157,598	201.6	-35,488	167.1	-81,735	76.8	-53,031	76.6	-66,884	167.1
18	68.0	62.1	-11,685	192.8	-285,936	176.7	-256,312	83.0	-291,803	82.8	-224,738	176.7
19	66.8	62.5	-230,397	136.8	-120,722	126.5	-191,851	82.7	-161,165	82.6	-151,407	126.5
20	65.4	62.0	-126,171	87.5	-445,521	80.5	-405,415	78.5	-435,656	78.4	-415,280	80.5
21	63.7	60.8	-438,013	75.3	-294,210	79.1	-352,232	77.2	-322,242	77.2	-324,200	79.1
22	61.9	59.5	-384,054	64.9	-697,454	69.4	-651,264	70.4	-680,946	70.4	-667,772	69.4
23	60.0	58.0	-686,293	60.4	-596,733	68.0	-623,868	68.9	-594,798	68.9	-625,803	68.0
24	58.2	56.3	-578,267	55.9	-989,561	59.7	-935,231	62.4	-964,066	62.4	-960,726	59.7

December			------ Design -----		----- Weekday -----		----- Saturday----		------ Sunday -----		------ Monday -----	
Hour	OADB	OAWB	Htg Btuh	Clg Ton	Htg Btuh	Clg Ton	Htg Btuh	Clg Ton	Htg Btuh	Clg Ton	Htg Btuh	Clg Ton
1	47.7	45.9	-1,176,115	50.3	-1,541,616	48.0	-1,735,267	48.3	-1,657,040	48.2	-1,777,015	48.1
2	46.2	44.5	-1,461,035	48.3	-1,881,858	47.5	-1,688,344	47.6	-1,777,405	47.6	-1,675,556	47.5
3	45.0	43.4	-1,335,883	47.1	-1,773,532	46.8	-1,960,151	46.8	-1,853,248	46.8	-1,934,636	46.8
4	44.3	42.7	-1,562,907	46.0	-1,984,917	46.4	-1,793,595	46.4	-1,906,649	46.4	-1,835,497	46.3
5	44.1	42.8	-1,414,694	45.2	-1,868,306	45.2	-2,058,330	45.2	-1,956,821	45.2	-2,049,727	45.2
6	44.6	43.1	-1,543,574	45.0	-1,997,324	44.9	-1,830,976	43.6	-1,911,327	43.6	-1,781,034	44.9
7	45.9	44.4	-1,098,410	61.1	-1,450,514	58.6	-1,920,915	42.2	-1,848,796	42.2	-1,669,297	58.6
8	48.0	46.5	-821,849	87.8	-1,183,199	81.3	-1,572,664	42.0	-1,646,462	42.0	-1,004,913	81.4
9	50.6	48.8	-651,368	94.8	-911,967	86.0	-1,126,957	59.0	-1,225,033	54.7	-932,042	86.2
10	53.6	51.0	-389,166	102.2	-721,747	90.2	-1,105,943	59.1	-1,101,891	54.0	-873,706	90.3
11	56.5	52.8	-256,768	111.9	-642,779	99.1	-777,272	63.9	-726,966	57.6	-574,729	99.1
12	59.1	54.3	-89,294	123.9	-471,766	109.4	-561,572	69.0	-736,887	61.5	-395,692	109.1
13	61.2	55.3	-52,280	141.0	-294,184	115.8	-419,400	71.9	-423,005	63.8	-294,184	116.2
14	62.6	56.2	-30,306	155.9	-172,429	122.2	-409,501	47.3	-436,061	46.4	-220,420	122.2
15	63.0	56.3	-24,560	163.2	-217,236	126.3	-340,628	50.0	-318,335	49.3	-169,756	126.3
16	62.8	56.2	-183,293	162.6	-198,072	128.4	-425,755	52.5	-355,263	51.9	-294,239	128.4
17	62.1	56.1	-47,707	149.4	-420,000	125.1	-546,466	52.8	-607,144	52.4	-324,095	125.1
18	61.0	56.8	-256,289	137.4	-334,274	127.6	-623,609	56.2	-540,129	55.9	-429,278	127.6
19	59.5	56.4	-291,091	96.2	-787,386	88.2	-765,702	57.9	-891,181	57.6	-678,931	88.2
20	57.7	55.1	-776,743	66.0	-772,505	59.8	-888,582	57.4	-768,721	57.2	-882,865	59.8
21	55.7	53.5	-668,914	61.1	-1,125,595	55.1	-1,044,882	53.3	-1,165,224	53.3	-1,017,076	55.1
22	53.6	51.3	-1,083,528	56.6	-1,101,152	49.5	-1,186,205	49.6	-1,066,474	49.5	-1,206,385	49.5
23	51.5	49.6	-961,996	54.1	-1,442,698	50.1	-1,348,994	50.3	-1,467,998	50.2	-1,340,916	50.1
24	49.5	47.8	-1,316,399	50.1	-1,443,686	48.8	-1,487,665	50.1	-1,369,151	50.1	-1,542,199	48.8

APPENDIX 4F

EVALUATION OF STORAGE STRATEGIES

12 HOUR TO 6 HOUR ON PEAK STORAGE SCENARIOS

12 HOUR ON-PEAK PERIOD (8 AM - 8 PM)

APRIL

Hour	Cooling Load (Ton-Hrs)	On Peak (Ton-Hrs)	Off Peak (Ton-Hrs)	Required Storage (Ton-Hrs)		Required Chiller (Tons)
1	87.2	0.0	87.2	254.58		341.8
2	81.4	0.0	81.4	254.58		336.0
3	76.6	0.0	76.6	254.58		331.2
4	71.6	0.0	71.6	254.58		326.2
5	71.4	0.0	71.4	254.58		326.0
6	102.9	0.0	102.9	254.58		357.5
7	160.6	0.0	160.6	254.58		415.2
8	186.2	186.2	0.0			0.0
9	205.4	205.4	0.0			0.0
10	213.1	213.1	0.0			0.0
11	244.5	244.5	0.0			0.0
12	266.1	266.1	0.0			0.0
13	283.6	283.6	0.0			0.0
14	298.9	298.9	0.0			0.0
15	307.9	307.9	0.0			0.0
16	307.0	307.0	0.0			0.0
17	299.6	299.6	0.0			0.0
18	245.6	245.6	0.0			0.0
19	197.1	197.1	0.0			0.0
20	184.1	0.0	184.1	254.58		438.7
21	156.0	0.0	156.0	254.58		410.6
22	135.9	0.0	135.9	254.58		390.5
23	117.8	0.0	117.8	254.58		372.4
24	107.8	0.0	107.8	254.58		362.4
TOTALS	4,408.3	3,055.0	1,353.3	3,055.0	MAX =	438.7

MAY

Hour	Cooling Load (Ton-Hrs)	On Peak (Ton-Hrs)	Off Peak (Ton-Hrs)	Required Storage (Ton-Hrs)		Required Chiller (Tons)
1	152.9	0.0	152.9	352.2		505.1
2	146.0	0.0	146.0	352.2		498.2
3	125.8	0.0	125.8	352.2		478.0
4	116.1	0.0	116.1	352.2		468.3
5	115.5	0.0	115.5	352.2		467.7
6	167.3	0.0	167.3	352.2		519.5
7	242.5	0.0	242.5	352.2		594.7
8	248.5	248.5	0.0			0.0
9	268.0	268.0	0.0			0.0
10	293.5	293.5	0.0			0.0
11	323.1	323.1	0.0			0.0
12	354.2	354.2	0.0			0.0
13	397.7	397.7	0.0			0.0
14	420.5	420.5	0.0			0.0
15	432.1	432.1	0.0			0.0
16	426.8	426.8	0.0			0.0
17	416.5	416.5	0.0			0.0
18	351.3	351.3	0.0			0.0
19	291.9	291.9	0.0			0.0
20	272.0	0.0	272.0	352.2		624.2
21	247.4	0.0	247.4	352.2		599.6
22	212.5	0.0	212.5	352.2		564.7
23	188.7	0.0	188.7	352.2		540.9
24	175.2	0.0	175.2	352.2		527.4
TOTALS	6,388.0	4,226.1	2,161.9	4,226.1	MAX =	624.2

JUNE

Hour	Cooling Load (Ton-Hrs)	On Peak (Ton-Hrs)	Off Peak (Ton-Hrs)	Required Storage (Ton-Hrs)		Required Chiller (Tons)
1	227.6	0.0	227.6	443.0		670.6
2	219.3	0.0	219.3	443.0		662.3
3	207.6	0.0	207.6	443.0		650.6
4	199.4	0.0	199.4	443.0		642.4
5	199.4	0.0	199.4	443.0		642.4
6	249.2	0.0	249.2	443.0		692.2
7	321.1	0.0	321.1	443.0		764.1
8	336.5	336.5	0.0			0.0
9	343.7	343.7	0.0			0.0
10	383.2	383.2	0.0			0.0
11	414.1	414.1	0.0			0.0
12	444.3	444.3	0.0			0.0
13	487.7	487.7	0.0			0.0
14	508.8	508.8	0.0			0.0
15	537.7	537.7	0.0			0.0
16	535.5	535.5	0.0			0.0
17	506.7	506.7	0.0			0.0
18	439.8	439.8	0.0			0.0
19	378.3	378.3	0.0			0.0
20	345.7	0.0	345.7	443.0		788.7
21	319.7	0.0	319.7	443.0		762.7
22	296.4	0.0	296.4	443.0		739.4
23	273.1	0.0	273.1	443.0		716.1
24	247.9	0.0	247.9	443.0		690.9
TOTALS	8,422.7	5,316.3	3,106.4	5,316.3	MAX =	788.7

JULY

Hour	Cooling Load (Ton-Hrs)	On Peak (Ton-Hrs)	Off Peak (Ton-Hrs)	Required Storage (Ton-Hrs)		Required Chiller (Tons)
1	254.9	0.0	254.9	466.1		721.0
2	238.8	0.0	238.8	466.1		704.9
3	229.2	0.0	229.2	466.1		695.3
4	221.5	0.0	221.5	466.1		687.6
5	222.0	0.0	222.0	466.1		688.1
6	269.6	0.0	269.6	466.1		735.7
7	344.4	0.0	344.4	466.1		810.5
8	357.7	357.7	0.0			0.0
9	378.6	378.6	0.0			0.0
10	401.4	401.4	0.0			0.0
11	428.0	428.0	0.0			0.0
12	473.6	473.6	0.0			0.0
13	516.2	516.2	0.0			0.0
14	537.3	537.3	0.0			0.0
15	560.6	560.6	0.0			0.0
16	546.8	546.8	0.0			0.0
17	534.4	534.4	0.0			0.0
18	467.6	467.6	0.0			0.0
19	390.6	390.6	0.0			0.0
20	372.5	0.0	372.5	466.1		838.6
21	335.7	0.0	335.7	466.1		801.8
22	311.2	0.0	311.2	466.1		777.3
23	290.3	0.0	290.3	466.1		756.4
24	264.7	0.0	264.7	466.1		730.8
TOTALS	8,947.6	5,592.8	3,354.8	5,592.8	MAX =	838.6

AUGUST

Hour	Cooling Load (Ton-Hrs)	On Peak (Ton-Hrs)	Off Peak (Ton-Hrs)	Required Storage (Ton-Hrs)		Required Chiller (Tons)
1	258.6	0.0	258.6	471.3		729.9
2	239.9	0.0	239.9	471.3		711.2
3	231.3	0.0	231.3	471.3		702.6
4	223.2	0.0	223.2	471.3		694.5
5	212.7	0.0	212.7	471.3		684.0
6	267.4	0.0	267.4	471.3		738.7
7	344.7	0.0	344.7	471.3		816.0
8	358.1	358.1	0.0			0.0
9	379.1	379.1	0.0			0.0
10	403.8	403.8	0.0			0.0
11	433.7	433.7	0.0			0.0
12	479.0	479.0	0.0			0.0
13	505.7	505.7	0.0			0.0
14	541.9	541.9	0.0			0.0
15	553.9	553.9	0.0			0.0
16	564.7	564.7	0.0			0.0
17	556.9	556.9	0.0			0.0
18	471.9	471.9	0.0			0.0
19	407.2	407.2	0.0			0.0
20	375.7	0.0	375.7	471.3		847.0
21	352.4	0.0	352.4	471.3		823.7
22	314.1	0.0	314.1	471.3		785.4
23	291.5	0.0	291.5	471.3		762.8
24	278.7	0.0	278.7	471.3		750.0
TOTALS	9,046.1	5,655.9	3,390.2	5,655.9	MAX =	847.0

SEPTEMBER

Hour	Cooling Load (Ton-Hrs)	On Peak (Ton-Hrs)	Off Peak (Ton-Hrs)	Required Storage (Ton-Hrs)		Required Chiller (Tons)
1	204.1	0.0	204.1	398.7		602.8
2	185.5	0.0	185.5	398.7		584.2
3	176.5	0.0	176.5	398.7		575.2
4	168.2	0.0	168.2	398.7		566.9
5	166.9	0.0	166.9	398.7		565.6
6	212.6	0.0	212.6	398.7		611.3
7	282.7	0.0	282.7	398.7		681.4
8	296.9	296.9	0.0			0.0
9	318.2	318.2	0.0			0.0
10	342.4	342.4	0.0			0.0
11	372.4	372.4	0.0			0.0
12	401.6	401.6	0.0			0.0
13	443.5	443.5	0.0			0.0
14	464.7	464.7	0.0			0.0
15	474.6	474.6	0.0			0.0
16	470.8	470.8	0.0			0.0
17	457.2	457.2	0.0			0.0
18	399.7	399.7	0.0			0.0
19	341.9	341.9	0.0			0.0
20	312.7	0.0	312.7	398.7		711.4
21	288.8	0.0	288.8	398.7		687.5
22	253.4	0.0	253.4	398.7		652.1
23	232.8	0.0	232.8	398.7		631.5
24	209.6	0.0	209.6	398.7		608.3
TOTALS	7,477.7	4,783.9	2,693.8	4,783.9	MAX =	711.4

OCTOBER

Hour	Cooling Load (Ton-Hrs)	On Peak (Ton-Hrs)	Off Peak (Ton-Hrs)	Required Storage (Ton-Hrs)		Required Chiller (Tons)
1	68.8	0.0	68.8	189.5		258.3
2	60.0	0.0	60.0	189.5		249.5
3	55.8	0.0	55.8	189.5		245.3
4	52.8	0.0	52.8	189.5		242.3
5	52.6	0.0	52.6	189.5		242.1
6	73.8	0.0	73.8	189.5		263.3
7	109.1	0.0	109.1	189.5		298.6
8	117.3	117.3	0.0			0.0
9	130.4	130.4	0.0			0.0
10	147.4	147.4	0.0			0.0
11	171.8	171.8	0.0			0.0
12	202.1	202.1	0.0			0.0
13	222.8	222.8	0.0			0.0
14	238.1	238.1	0.0			0.0
15	246.6	246.6	0.0			0.0
16	243.5	243.5	0.0			0.0
17	232.5	232.5	0.0			0.0
18	183.7	183.7	0.0			0.0
19	137.2	137.2	0.0			0.0
20	113.3	0.0	113.3	189.5		302.8
21	94.3	0.0	94.3	189.5		283.8
22	78.5	0.0	78.5	189.5		268.0
23	68.3	0.0	68.3	189.5		257.8
24	61.3	0.0	61.3	189.5		250.8
TOTALS	3,162.0	2,273.4	888.6	2,273.4	MAX =	302.8

NOVEMBER

Hour	Cooling Load (Ton-Hrs)	On Peak (Ton-Hrs)	Off Peak (Ton-Hrs)	Required Storage (Ton-Hrs)		Required Chiller (Tons)
1	55.8	0.0	55.8	169.0		224.8
2	53.1	0.0	53.1	169.0		222.1
3	51.1	0.0	51.1	169.0		220.1
4	48.3	0.0	48.3	169.0		217.3
5	47.2	0.0	47.2	169.0		216.2
6	46.9	0.0	46.9	169.0		215.9
7	67.0	0.0	67.0	169.0		236.0
8	104.9	104.9	0.0			0.0
9	114.0	114.0	0.0			0.0
10	125.7	125.7	0.0			0.0
11	145.8	145.8	0.0			0.0
12	173.7	173.7	0.0			0.0
13	194.3	194.3	0.0			0.0
14	208.5	208.5	0.0			0.0
15	216.0	216.0	0.0			0.0
16	214.2	214.2	0.0			0.0
17	201.6	201.6	0.0			0.0
18	192.8	192.8	0.0			0.0
19	136.8	136.8	0.0			0.0
20	87.5	0.0	87.5	169.0		256.5
21	75.3	0.0	75.3	169.0		244.3
22	64.9	0.0	64.9	169.0		233.9
23	60.4	0.0	60.4	169.0		229.4
24	55.9	0.0	55.9	169.0		224.9
TOTALS	2,741.7	2,028.3	713.4	2,028.3	MAX =	256.5

11 HOUR ON-PEAK PERIOD (8 AM - 7 PM)

APRIL

Hour	Cooling Load (Ton-Hrs)	On Peak (Ton-Hrs)	Off Peak (Ton-Hrs)	Required Storage (Ton-Hrs)		Required Chiller (Tons)
1	87.2	0.0	87.2	219.84		307.0
2	81.4	0.0	81.4	219.84		301.2
3	76.6	0.0	76.6	219.84		296.4
4	71.6	0.0	71.6	219.84		291.4
5	71.4	0.0	71.4	219.84		291.2
6	102.9	0.0	102.9	219.84		322.7
7	160.6	0.0	160.6	219.84		380.4
8	186.2	186.2	0.0			0.0
9	205.4	205.4	0.0			0.0
10	213.1	213.1	0.0			0.0
11	244.5	244.5	0.0			0.0
12	266.1	266.1	0.0			0.0
13	283.6	283.6	0.0			0.0
14	296.9	296.9	0.0			0.0
15	307.9	307.9	0.0			0.0
16	307.0	307.0	0.0			0.0
17	299.6	299.6	0.0			0.0
18	245.6	245.6	0.0			0.0
19	197.1	0.0	197.1	219.84		416.9
20	184.1	0.0	184.1	219.84		403.9
21	156.0	0.0	156.0	219.84		375.8
22	135.9	0.0	135.9	219.84		355.7
23	117.8	0.0	117.8	219.84		337.6
24	107.8	0.0	107.8	219.84		327.6
TOTALS	4,408.3	2,857.9	1,550.4	2,857.9	MAX =	416.9

MAY

Hour	Cooling Load (Ton-Hrs)	On Peak (Ton-Hrs)	Off Peak (Ton-Hrs)	Required Storage (Ton-Hrs)		Required Chiller (Tons)
1	152.9	0.0	152.9	302.6		455.5
2	146.0	0.0	146.0	302.6		448.6
3	125.8	0.0	125.8	302.6		428.4
4	116.1	0.0	116.1	302.6		418.7
5	115.5	0.0	115.5	302.6		418.1
6	167.3	0.0	167.3	302.6		469.9
7	242.5	0.0	242.5	302.6		545.1
8	248.5	248.5	0.0			0.0
9	268.0	268.0	0.0			0.0
10	293.5	293.5	0.0			0.0
11	323.1	323.1	0.0			0.0
12	354.2	354.2	0.0			0.0
13	397.7	397.7	0.0			0.0
14	420.5	420.5	0.0			0.0
15	432.1	432.1	0.0			0.0
16	428.8	428.8	0.0			0.0
17	416.5	416.5	0.0			0.0
18	351.3	351.3	0.0			0.0
19	291.9	0.0	291.9	302.6		594.5
20	272.0	0.0	272.0	302.6		574.6
21	247.4	0.0	247.4	302.6		550.0
22	212.5	0.0	212.5	302.6		515.1
23	188.7	0.0	188.7	302.6		491.3
24	175.2	0.0	175.2	302.6		477.8
TOTALS	6,388.0	3,934.2	2,453.8	3,934.2	MAX =	594.5

JUNE

Hour	Cooling Load (Ton-Hrs)	On Peak (Ton-Hrs)	Off Peak (Ton-Hrs)	Required Storage (Ton-Hrs)		Required Chiller (Tons)
1	227.6	0.0	227.6	379.8		607.4
2	219.3	0.0	219.3	379.8		599.1
3	207.6	0.0	207.6	379.8		587.4
4	199.4	0.0	199.4	379.8		579.2
5	199.4	0.0	199.4	379.8		579.2
6	249.2	0.0	249.2	379.8		629.0
7	321.1	0.0	321.1	379.8		700.9
8	336.5	336.5	0.0			0.0
9	343.7	343.7	0.0			0.0
10	383.2	383.2	0.0			0.0
11	414.1	414.1	0.0			0.0
12	444.3	444.3	0.0			0.0
13	487.7	487.7	0.0			0.0
14	506.8	506.8	0.0			0.0
15	537.7	537.7	0.0			0.0
16	535.5	535.5	0.0			0.0
17	506.7	506.7	0.0			0.0
18	439.8	439.8	0.0			0.0
19	378.3	0.0	378.3	379.8		758.1
20	345.7	0.0	345.7	379.8		725.5
21	319.7	0.0	319.7	379.8		699.5
22	296.4	0.0	296.4	379.8		676.2
23	273.1	0.0	273.1	379.8		652.9
24	247.9	0.0	247.9	379.8		627.7
TOTALS	8,422.7	4,938.0	3,484.7	4,938.0	MAX =	758.1

JULY

Hour	Cooling Load (Ton-Hrs)	On Peak (Ton-Hrs)	Off Peak (Ton-Hrs)	Required Storage (Ton-Hrs)		Required Chiller (Tons)
1	254.9	0.0	254.9	400.2		655.1
2	238.8	0.0	238.8	400.2		639.0
3	229.2	0.0	229.2	400.2		629.4
4	221.5	0.0	221.5	400.2		621.7
5	222.0	0.0	222.0	400.2		622.2
6	255.6	0.0	269.6	400.2		669.8
7	344.4	0.0	344.4	400.2		744.6
8	357.7	357.7	0.0			0.0
9	378.6	378.6	0.0			0.0
10	401.4	401.4	0.0			0.0
11	428.0	428.0	0.0			0.0
12	473.6	473.6	0.0			0.0
13	516.2	516.2	0.0			0.0
14	537.3	537.3	0.0			0.0
15	560.6	560.6	0.0			0.0
16	546.8	546.8	0.0			0.0
17	534.4	534.4	0.0			0.0
18	467.6	467.6	0.0			0.0
19	390.6	0.0	390.6	400.2		790.8
20	372.5	0.0	372.5	400.2		772.7
21	335.7	0.0	335.7	400.2		735.9
22	311.2	0.0	311.2	400.2		711.4
23	290.3	0.0	290.3	400.2		690.5
24	254.7	0.0	264.7	400.2		664.9
TOTALS	8,947.6	5,202.2	3,745.4	5,202.2	MAX =	790.8

AUGUST

Hour	Cooling Load (Ton-Hrs)	On Peak (Ton-Hrs)	Off Peak (Ton-Hrs)	Required Storage (Ton-Hrs)		Required Chiller (Tons)
1	258.6	0.0	258.6	403.7		662.3
2	239.9	0.0	239.9	403.7		643.6
3	231.3	0.0	231.3	403.7		635.0
4	223.2	0.0	223.2	403.7		626.9
5	212.7	0.0	212.7	403.7		616.4
6	267.4	0.0	267.4	403.7		671.1
7	344.7	0.0	344.7	403.7		748.4
8	358.1	358.1	0.0			0.0
9	379.1	379.1	0.0			0.0
10	403.8	403.8	0.0			0.0
11	433.7	433.7	0.0			0.0
12	479.0	479.0	0.0			0.0
13	505.7	505.7	0.0			0.0
14	541.9	541.9	0.0			0.0
15	553.9	553.9	0.0			0.0
16	564.7	564.7	0.0			0.0
17	556.9	556.9	0.0			0.0
18	471.9	471.9	0.0			0.0
19	407.2	0.0	407.2	403.7		810.9
20	375.7	0.0	375.7	403.7		779.4
21	352.4	0.0	352.4	403.7		756.1
22	314.1	0.0	314.1	403.7		717.8
23	291.5	0.0	291.5	403.7		695.2
24	278.7	0.0	278.7	403.7		682.4
TOTALS	**9,046.1**	**5,248.7**	**3,797.4**	**5,248.7**	**MAX =**	**810.9**

SEPTEMBER

Hour	Cooling Load (Ton-Hrs)	On Peak (Ton-Hrs)	Off Peak (Ton-Hrs)	Required Storage (Ton-Hrs)		Required Chiller (Tons)
1	204.1	0.0	204.1	341.7		545.8
2	185.5	0.0	185.5	341.7		527.2
3	176.5	0.0	176.5	341.7		518.2
4	168.2	0.0	168.2	341.7		509.9
5	166.9	0.0	166.9	341.7		508.6
6	212.6	0.0	212.6	341.7		554.3
7	282.7	0.0	282.7	341.7		624.4
8	296.9	296.9	0.0			0.0
9	318.2	318.2	0.0			0.0
10	342.4	342.4	0.0			0.0
11	372.4	372.4	0.0			0.0
12	401.6	401.6	0.0			0.0
13	443.5	443.5	0.0			0.0
14	464.7	464.7	0.0			0.0
15	474.6	474.6	0.0			0.0
16	470.8	470.8	0.0			0.0
17	457.2	457.2	0.0			0.0
18	399.7	399.7	0.0			0.0
19	341.9	0.0	341.9	341.7		683.6
20	312.7	0.0	312.7	341.7		654.4
21	288.8	0.0	288.8	341.7		630.5
22	253.4	0.0	253.4	341.7		595.1
23	232.8	0.0	232.8	341.7		574.5
24	209.6	0.0	209.6	341.7		551.3
TOTALS	**7,477.7**	**4,442.0**	**3,035.7**	**4,442.0**	**MAX =**	**683.6**

OCTOBER

Hour	Cooling Load (Ton-Hrs)	On Peak (Ton-Hrs)	Off Peak (Ton-Hrs)	Required Storage (Ton-Hrs)		Required Chiller (Tons)
1	68.8	0.0	68.8	164.3		233.1
2	60.0	0.0	60.0	164.3		224.3
3	55.8	0.0	55.8	164.3		220.1
4	52.8	0.0	52.8	164.3		217.1
5	52.6	0.0	52.6	164.3		216.9
6	73.8	0.0	73.8	164.3		238.1
7	109.1	0.0	109.1	164.3		273.4
8	117.3	117.3	0.0			0.0
9	130.4	130.4	0.0			0.0
10	147.4	147.4	0.0			0.0
11	171.8	171.8	0.0			0.0
12	202.1	202.1	0.0			0.0
13	222.8	222.8	0.0			0.0
14	236.1	236.1	0.0			0.0
15	246.6	246.6	0.0			0.0
16	243.5	243.5	0.0			0.0
17	232.5	232.5	0.0			0.0
18	183.7	183.7	0.0			0.0
19	137.2	0.0	137.2	164.3		301.5
20	113.3	0.0	113.3	164.3		277.6
21	94.3	0.0	94.3	164.3		258.6
22	78.5	0.0	78.5	164.3		242.8
23	68.3	0.0	68.3	164.3		232.6
24	61.3	0.0	61.3	164.3		225.6
TOTALS	3,162.0	2,136.2	1,025.8	2,136.2	MAX =	301.5

NOVEMBER

Hour	Cooling Load (Ton-Hrs)	On Peak (Ton-Hrs)	Off Peak (Ton-Hrs)	Required Storage (Ton-Hrs)		Required Chiller (Tons)
1	55.8	0.0	55.8	145.5		201.3
2	53.1	0.0	53.1	145.5		198.6
3	51.1	0.0	51.1	145.5		196.6
4	48.3	0.0	48.3	145.5		193.8
5	47.2	0.0	47.2	145.5		192.7
6	46.9	0.0	46.9	145.5		192.4
7	67.0	0.0	67.0	145.5		212.5
8	104.9	104.9	0.0			0.0
9	114.0	114.0	0.0			0.0
10	125.7	125.7	0.0			0.0
11	145.8	145.8	0.0			0.0
12	173.7	173.7	0.0			0.0
13	194.3	194.3	0.0			0.0
14	206.5	206.5	0.0			0.0
15	216.0	216.0	0.0			0.0
16	214.2	214.2	0.0			0.0
17	201.6	201.6	0.0			0.0
18	192.8	192.8	0.0			0.0
19	136.8	0.0	136.8	145.5		282.3
20	87.5	0.0	87.5	145.5		233.0
21	75.3	0.0	75.3	145.5		220.8
22	64.9	0.0	64.9	145.5		210.4
23	60.4	0.0	60.4	145.5		205.9
24	55.9	0.0	55.9	145.5		201.4
TOTALS	2,741.7	1,891.5	850.2	1,891.5	MAX =	282.3

10 HOUR ON-PEAK PERIOD (8 AM - 6 PM)

APRIL

Hour	Cooling Load (Ton-Hrs)	On Peak (Ton-Hrs)	Off Peak (Ton-Hrs)	Required Storage (Ton-Hrs)		Required Chiller (Tons)
1	87.2	0.0	87.2	186.59		273.8
2	81.4	0.0	81.4	186.59		268.0
3	76.6	0.0	76.6	186.59		263.2
4	71.6	0.0	71.6	186.59		258.2
5	71.4	0.0	71.4	186.59		258.0
6	102.9	0.0	102.9	186.59		289.5
7	160.6	0.0	160.6	186.59		347.2
8	186.2	186.2	0.0			0.0
9	205.4	205.4	0.0			0.0
10	213.1	213.1	0.0			0.0
11	244.5	244.5	0.0			0.0
12	266.1	266.1	0.0			0.0
13	283.6	283.6	0.0			0.0
14	298.9	298.9	0.0			0.0
15	307.9	307.9	0.0			0.0
16	307.0	307.0	0.0			0.0
17	299.6	299.6	0.0			0.0
18	245.6	0.0	245.6	186.59		432.2
19	197.1	0.0	197.1	186.59		383.7
20	184.1	0.0	184.1	186.59		370.7
21	156.0	0.0	156.0	186.59		342.6
22	135.9	0.0	135.9	186.59		322.5
23	117.8	0.0	117.8	186.59		304.4
24	107.8	0.0	107.8	186.59		294.4
TOTALS	4,408.3	2,612.3	1,796.0	2,612.3	MAX =	432.2

MAY

Hour	Cooling Load (Ton-Hrs)	On Peak (Ton-Hrs)	Off Peak (Ton-Hrs)	Required Storage (Ton-Hrs)		Required Chiller (Tons)
1	152.9	0.0	152.9	255.9		408.8
2	146.0	0.0	146.0	255.9		401.9
3	125.8	0.0	125.8	255.9		381.7
4	116.1	0.0	116.1	255.9		372.0
5	115.5	0.0	115.5	255.9		371.4
6	167.3	0.0	167.3	255.9		423.2
7	242.5	0.0	242.5	255.9		498.4
8	248.5	248.5	0.0			0.0
9	268.0	268.0	0.0			0.0
10	293.5	293.5	0.0			0.0
11	323.1	323.1	0.0			0.0
12	354.2	354.2	0.0			0.0
13	397.7	397.7	0.0			0.0
14	420.5	420.5	0.0			0.0
15	432.1	432.1	0.0			0.0
16	428.8	428.8	0.0			0.0
17	416.5	416.5	0.0			0.0
18	351.3	0.0	351.3	255.9		607.2
19	291.9	0.0	291.9	255.9		547.8
20	272.0	0.0	272.0	255.9		527.9
21	247.4	0.0	247.4	255.9		503.3
22	212.5	0.0	212.5	255.9		468.4
23	188.7	0.0	188.7	255.9		444.6
24	175.2	0.0	175.2	255.9		431.1
TOTALS	6,388.0	3,582.9	2,805.1	3,582.9	MAX =	607.2

JUNE

Hour	Cooling Load (Ton-Hrs)	On Peak (Ton-Hrs)	Off Peak (Ton-Hrs)	Required Storage (Ton-Hrs)		Required Chiller (Tons)
1	227.6	0.0	227.6	321.3		548.9
2	219.3	0.0	219.3	321.3		540.6
3	207.6	0.0	207.6	321.3		528.9
4	199.4	0.0	199.4	321.3		520.7
5	199.4	0.0	199.4	321.3		520.7
6	249.2	0.0	249.2	321.3		570.5
7	321.1	0.0	321.1	321.3		642.4
8	336.5	336.5	0.0			0.0
9	343.7	343.7	0.0			0.0
10	383.2	383.2	0.0			0.0
11	414.1	414.1	0.0			0.0
12	444.3	444.3	0.0			0.0
13	487.7	487.7	0.0			0.0
14	506.8	506.8	0.0			0.0
15	537.7	537.7	0.0			0.0
16	535.5	535.5	0.0			0.0
17	506.7	506.7	0.0			0.0
18	439.8	0.0	439.8	321.3		761.1
19	378.3	0.0	378.3	321.3		699.6
20	345.7	0.0	345.7	321.3		667.0
21	319.7	0.0	319.7	321.3		641.0
22	296.4	0.0	296.4	321.3		617.7
23	273.1	0.0	273.1	321.3		594.4
24	247.9	0.0	247.9	321.3		569.2
TOTALS	8,422.7	4,498.2	3,924.5	4,498.2	MAX =	761.1

JULY

Hour	Cooling Load (Ton-Hrs)	On Peak (Ton-Hrs)	Off Peak (Ton-Hrs)	Required Storage (Ton-Hrs)		Required Chiller (Tons)
1	254.9	0.0	254.9	338.2		593.1
2	238.8	0.0	238.8	338.2		577.0
3	229.2	0.0	229.2	338.2		567.4
4	221.5	0.0	221.5	338.2		559.7
5	222.0	0.0	222.0	338.2		560.2
6	269.6	0.0	269.6	338.2		607.8
7	344.4	0.0	344.4	338.2		682.6
8	357.7	357.7	0.0			0.0
9	378.6	378.6	0.0			0.0
10	401.4	401.4	0.0			0.0
11	428.0	428.0	0.0			0.0
12	473.6	473.6	0.0			0.0
13	516.2	516.2	0.0			0.0
14	537.3	537.3	0.0			0.0
15	560.6	560.6	0.0			0.0
16	546.8	546.8	0.0			0.0
17	534.4	534.4	0.0			0.0
18	467.6	0.0	467.6	338.2		805.8
19	390.6	0.0	390.6	338.2		728.8
20	372.5	0.0	372.5	338.2		710.7
21	335.7	0.0	335.7	338.2		673.9
22	311.2	0.0	311.2	338.2		649.4
23	290.3	0.0	290.3	338.2		628.5
24	264.7	0.0	264.7	338.2		602.9
TOTALS	8,947.6	4,734.6	4,213.0	4,734.6	MAX =	805.8

AUGUST

Hour	Cooling Load (Ton-Hrs)	On Peak (Ton-Hrs)	Off Peak (Ton-Hrs)	Required Storage (Ton-Hrs)		Required Chiller (Tons)
1	258.6	0.0	258.6	341.2		599.8
2	239.9	0.0	239.9	341.2		581.1
3	231.3	0.0	231.3	341.2		572.5
4	223.2	0.0	223.2	341.2		564.4
5	212.7	0.0	212.7	341.2		553.9
6	267.4	0.0	267.4	341.2		608.6
7	344.7	0.0	344.7	341.2		685.9
8	358.1	358.1	0.0			0.0
9	379.1	379.1	0.0			0.0
10	403.8	403.8	0.0			0.0
11	433.7	433.7	0.0			0.0
12	479.0	479.0	0.0			0.0
13	505.7	505.7	0.0			0.0
14	541.9	541.9	0.0			0.0
15	553.9	553.9	0.0			0.0
16	564.7	564.7	0.0			0.0
17	556.9	556.9	0.0			0.0
18	471.9	0.0	471.9	341.2		813.1
19	407.2	0.0	407.2	341.2		748.4
20	375.7	0.0	375.7	341.2		716.9
21	352.4	0.0	352.4	341.2		693.6
22	314.1	0.0	314.1	341.2		655.3
23	291.5	0.0	291.5	341.2		632.7
24	278.7	0.0	278.7	341.2		619.9
TOTALS	9,046.1	4,776.8	4,269.3	4,776.8	MAX =	813.1

SEPTEMBER

Hour	Cooling Load (Ton-Hrs)	On Peak (Ton-Hrs)	Off Peak (Ton-Hrs)	Required Storage (Ton-Hrs)		Required Chiller (Tons)
1	204.1	0.0	204.1	288.7		492.8
2	185.5	0.0	185.5	288.7		474.2
3	176.5	0.0	176.5	288.7		465.2
4	168.2	0.0	168.2	288.7		456.9
5	166.9	0.0	166.9	288.7		455.6
6	212.6	0.0	212.6	288.7		501.3
7	282.7	0.0	282.7	288.7		571.4
8	296.9	296.9	0.0			0.0
9	318.2	318.2	0.0			0.0
10	342.4	342.4	0.0			0.0
11	372.4	372.4	0.0			0.0
12	401.6	401.6	0.0			0.0
13	443.5	443.5	0.0			0.0
14	464.7	464.7	0.0			0.0
15	474.6	474.6	0.0			0.0
16	470.8	470.8	0.0			0.0
17	457.2	457.2	0.0			0.0
18	399.7	0.0	399.7	288.7		688.4
19	341.9	0.0	341.9	288.7		630.6
20	312.7	0.0	312.7	288.7		601.4
21	288.8	0.0	288.8	288.7		577.5
22	253.4	0.0	253.4	288.7		542.1
23	232.8	0.0	232.8	288.7		521.5
24	209.6	0.0	209.6	288.7		498.3
TOTALS	7,477.7	4,042.3	3,435.4	4,042.3	MAX =	688.4

OCTOBER

Hour	Cooling Load (Ton-Hrs)	On Peak (Ton-Hrs)	Off Peak (Ton-Hrs)	Required Storage (Ton-Hrs)		Required Chiller (Tons)
1	68.8	0.0	68.8	139.5		208.3
2	60.0	0.0	60.0	139.5		199.5
3	55.8	0.0	55.8	139.5		195.3
4	52.8	0.0	52.8	139.5		192.3
5	52.6	0.0	52.6	139.5		192.1
6	73.8	0.0	73.8	139.5		213.3
7	109.1	0.0	109.1	139.5		248.6
8	117.3	117.3	0.0			0.0
9	130.4	130.4	0.0			0.0
10	147.4	147.4	0.0			0.0
11	171.8	171.8	0.0			0.0
12	202.1	202.1	0.0			0.0
13	222.8	222.8	0.0			0.0
14	238.1	238.1	0.0			0.0
15	246.6	246.6	0.0			0.0
16	243.5	243.5	0.0			0.0
17	232.5	232.5	0.0			0.0
18	183.7	0.0	183.7	139.5		323.2
19	137.2	0.0	137.2	139.5		276.7
20	113.3	0.0	113.3	139.5		252.8
21	94.3	0.0	94.3	139.5		233.8
22	78.5	0.0	78.5	139.5		218.0
23	68.3	0.0	68.3	139.5		207.8
24	61.3	0.0	61.3	139.5		200.8
TOTALS	3,162.0	1,952.5	1,209.5	1,952.5	MAX =	323.2

NOVEMBER

Hour	Cooling Load (Ton-Hrs)	On Peak (Ton-Hrs)	Off Peak (Ton-Hrs)	Required Storage (Ton-Hrs)		Required Chiller (Tons)
1	55.8	0.0	55.8	121.3		177.1
2	53.1	0.0	53.1	121.3		174.4
3	51.1	0.0	51.1	121.3		172.4
4	48.3	0.0	48.3	121.3		169.6
5	47.2	0.0	47.2	121.3		168.5
6	46.9	0.0	46.9	121.3		168.2
7	67.0	0.0	67.0	121.3		188.3
8	104.9	104.9	0.0			0.0
9	114.0	114.0	0.0			0.0
10	125.7	125.7	0.0			0.0
11	145.8	145.8	0.0			0.0
12	173.7	173.7	0.0			0.0
13	194.3	194.3	0.0			0.0
14	208.5	208.5	0.0			0.0
15	216.0	216.0	0.0			0.0
16	214.2	214.2	0.0			0.0
17	201.6	201.6	0.0			0.0
18	192.8	0.0	192.8	121.3		314.1
19	136.8	0.0	136.8	121.3		258.1
20	87.5	0.0	87.5	121.3		208.8
21	75.3	0.0	75.3	121.3		196.6
22	64.9	0.0	64.9	121.3		186.2
23	60.4	0.0	60.4	121.3		181.7
24	55.9	0.0	55.9	121.3		177.2
TOTALS	2,741.7	1,698.7	1,043.0	1,698.7	MAX =	314.1

9 HOUR ON-PEAK PERIOD (9 AM - 6 PM)

APRIL

Hour	Cooling Load (Ton-Hrs)	On Peak (Ton-Hrs)	Off Peak (Ton-Hrs)	Required Storage (Ton-Hrs)		Required Chiller (Tons)
1	87.2	0.0	87.2	161.74		248.9
2	81.4	0.0	81.4	161.74		243.1
3	76.6	0.0	76.6	161.74		238.3
4	71.6	0.0	71.6	161.74		233.3
5	71.4	0.0	71.4	161.74		233.1
6	102.9	0.0	102.9	161.74		264.6
7	160.6	0.0	160.6	161.74		322.3
8	186.2	0.0	186.2	161.74		347.9
9	205.4	205.4	0.0			0.0
10	213.1	213.1	0.0			0.0
11	244.5	244.5	0.0			0.0
12	266.1	266.1	0.0			0.0
13	283.6	283.6	0.0			0.0
14	298.9	298.9	0.0			0.0
15	307.9	307.9	0.0			0.0
16	307.0	307.0	0.0			0.0
17	299.6	299.6	0.0			0.0
18	245.6	0.0	245.6	161.74		407.3
19	197.1	0.0	197.1	161.74		358.8
20	184.1	0.0	184.1	161.74		345.8
21	156.0	0.0	156.0	161.74		317.7
22	135.9	0.0	135.9	161.74		297.6
23	117.8	0.0	117.8	161.74		279.5
24	107.8	0.0	107.8	161.74		269.5
TOTALS	4,408.3	2,426.1	1,982.2	2,426.1	MAX =	407.3

MAY

Hour	Cooling Load (Ton-Hrs)	On Peak (Ton-Hrs)	Off Peak (Ton-Hrs)	Required Storage (Ton-Hrs)		Required Chiller (Tons)
1	152.9	0.0	152.9	222.3		375.2
2	146.0	0.0	146.0	222.3		368.3
3	125.8	0.0	125.8	222.3		348.1
4	116.1	0.0	116.1	222.3		338.4
5	115.5	0.0	115.5	222.3		337.8
6	167.3	0.0	167.3	222.3		389.6
7	242.5	0.0	242.5	222.3		464.8
8	248.5	0.0	248.5	222.3		470.8
9	268.0	268.0	0.0			0.0
10	293.5	293.5	0.0			0.0
11	323.1	323.1	0.0			0.0
12	354.2	354.2	0.0			0.0
13	397.7	397.7	0.0			0.0
14	420.5	420.5	0.0			0.0
15	432.1	432.1	0.0			0.0
16	428.8	428.8	0.0			0.0
17	416.5	416.5	0.0			0.0
18	351.3	0.0	351.3	222.3		573.6
19	291.9	0.0	291.9	222.3		514.2
20	272.0	0.0	272.0	222.3		494.3
21	247.4	0.0	247.4	222.3		469.7
22	212.5	0.0	212.5	222.3		434.8
23	188.7	0.0	188.7	222.3		411.0
24	175.2	0.0	175.2	222.3		397.5
TOTALS	6,388.0	3,334.4	3,053.6	3,334.4	MAX =	573.6

JUNE

Hour	Cooling Load (Ton-Hrs)	On Peak (Ton-Hrs)	Off Peak (Ton-Hrs)	Required Storage (Ton-Hrs)		Required Chiller (Tons)
1	227.6	0.0	227.6	277.4		505.0
2	219.3	0.0	219.3	277.4		496.7
3	207.6	0.0	207.6	277.4		485.0
4	199.4	0.0	199.4	277.4		476.8
5	199.4	0.0	199.4	277.4		476.8
6	249.2	0.0	249.2	277.4		526.6
7	321.1	0.0	321.1	277.4		598.5
8	336.5	0.0	336.5	277.4		613.9
9	343.7	343.7	0.0			0.0
10	383.2	383.2	0.0			0.0
11	414.1	414.1	0.0			0.0
12	444.3	444.3	0.0			0.0
13	487.7	487.7	0.0			0.0
14	508.8	508.8	0.0			0.0
15	537.7	537.7	0.0			0.0
16	535.5	535.5	0.0			0.0
17	506.7	506.7	0.0			0.0
18	439.8	0.0	439.8	277.4		717.2
19	378.3	0.0	378.3	277.4		655.7
20	345.7	0.0	345.7	277.4		623.1
21	319.7	0.0	319.7	277.4		597.1
22	296.4	0.0	296.4	277.4		573.8
23	273.1	0.0	273.1	277.4		550.5
24	247.9	0.0	247.9	277.4		525.3
TOTALS	8,422.7	4,161.7	4,261.0	4,161.7	MAX =	717.2

JULY

Hour	Cooling Load (Ton-Hrs)	On Peak (Ton-Hrs)	Off Peak (Ton-Hrs)	Required Storage (Ton-Hrs)		Required Chiller (Tons)
1	254.9	0.0	254.9	291.8		546.7
2	238.8	0.0	238.8	291.8		530.6
3	229.2	0.0	229.2	291.8		521.0
4	221.5	0.0	221.5	291.8		513.3
5	222.0	0.0	222.0	291.8		513.8
6	269.6	0.0	269.6	291.8		561.4
7	344.4	0.0	344.4	291.8		636.2
8	357.7	0.0	357.7	291.8		649.5
9	378.6	378.6	0.0			0.0
10	401.4	401.4	0.0			0.0
11	428.0	428.0	0.0			0.0
12	473.6	473.6	0.0			0.0
13	516.2	516.2	0.0			0.0
14	537.3	537.3	0.0			0.0
15	560.6	560.6	0.0			0.0
16	546.8	546.8	0.0			0.0
17	534.4	534.4	0.0			0.0
18	467.6	0.0	467.6	291.8		759.4
19	390.6	0.0	390.6	291.8		682.4
20	372.5	0.0	372.5	291.8		664.3
21	335.7	0.0	335.7	291.8		627.5
22	311.2	0.0	311.2	291.8		603.0
23	290.3	0.0	290.3	291.8		582.1
24	264.7	0.0	264.7	291.8		556.5
TOTALS	8,947.6	4,376.9	4,570.7	4,376.9	MAX =	759.4

AUGUST

Hour	Cooling Load (Ton-Hrs)	On Peak (Ton-Hrs)	Off Peak (Ton-Hrs)	Required Storage (Ton-Hrs)		Required Chiller (Tons)
1	258.6	0.0	258.6	294.6		553.2
2	239.9	0.0	239.9	294.6		534.5
3	231.3	0.0	231.3	294.6		525.9
4	223.2	0.0	223.2	294.6		517.8
5	212.7	0.0	212.7	294.6		507.3
6	267.4	0.0	267.4	294.6		562.0
7	344.7	0.0	344.7	294.6		639.3
8	358.1	0.0	358.1	294.6		652.7
9	379.1	379.1	0.0			0.0
10	403.8	403.8	0.0			0.0
11	433.7	433.7	0.0			0.0
12	479.0	479.0	0.0			0.0
13	505.7	505.7	0.0			0.0
14	541.9	541.9	0.0			0.0
15	553.9	553.9	0.0			0.0
16	564.7	564.7	0.0			0.0
17	556.9	556.9	0.0			0.0
18	471.9	0.0	471.9	294.6		766.5
19	407.2	0.0	407.2	294.6		701.8
20	375.7	0.0	375.7	294.6		670.3
21	352.4	0.0	352.4	294.6		647.0
22	314.1	0.0	314.1	294.6		608.7
23	291.5	0.0	291.5	294.6		586.1
24	278.7	0.0	278.7	294.6		573.3
TOTALS	9,046.1	4,418.7	4,627.4	4,418.7	MAX =	766.5

SEPTEMBER

Hour	Cooling Load (Ton-Hrs)	On Peak (Ton-Hrs)	Off Peak (Ton-Hrs)	Required Storage (Ton-Hrs)		Required Chiller (Tons)
1	204.1	0.0	204.1	249.7		453.8
2	185.5	0.0	185.5	249.7		435.2
3	176.5	0.0	176.5	249.7		426.2
4	168.2	0.0	168.2	249.7		417.9
5	166.9	0.0	166.9	249.7		416.6
6	212.6	0.0	212.6	249.7		462.3
7	282.7	0.0	282.7	249.7		532.4
8	296.9	0.0	296.9	249.7		546.6
9	318.2	318.2	0.0			0.0
10	342.4	342.4	0.0			0.0
11	372.4	372.4	0.0			0.0
12	401.6	401.6	0.0			0.0
13	443.5	443.5	0.0			0.0
14	464.7	464.7	0.0			0.0
15	474.6	474.6	0.0			0.0
16	470.8	470.8	0.0			0.0
17	457.2	457.2	0.0			0.0
18	399.7	0.0	399.7	249.7		649.4
19	341.9	0.0	341.9	249.7		591.6
20	312.7	0.0	312.7	249.7		562.4
21	288.8	0.0	288.8	249.7		538.5
22	253.4	0.0	253.4	249.7		503.1
23	232.8	0.0	232.8	249.7		482.5
24	209.6	0.0	209.6	249.7		459.3
TOTALS	7,477.7	3,745.4	3,732.3	3,745.4	MAX =	649.4

OCTOBER

Hour	Cooling Load (Ton-Hrs)	On Peak (Ton-Hrs)	Off Peak (Ton-Hrs)	Required Storage (Ton-Hrs)		Required Chiller (Tons)
1	68.8	0.0	68.8	122.3		191.1
2	60.0	0.0	60.0	122.3		182.3
3	55.8	0.0	55.8	122.3		178.1
4	52.8	0.0	52.8	122.3		175.1
5	52.6	0.0	52.6	122.3		174.9
6	73.8	0.0	73.8	122.3		196.1
7	109.1	0.0	109.1	122.3		231.4
8	117.3	0.0	117.3	122.3		239.6
9	130.4	130.4	0.0			0.0
10	147.4	147.4	0.0			0.0
11	171.8	171.8	0.0			0.0
12	202.1	202.1	0.0			0.0
13	222.8	222.8	0.0			0.0
14	238.1	238.1	0.0			0.0
15	246.6	246.6	0.0			0.0
16	243.5	243.5	0.0			0.0
17	232.5	232.5	0.0			0.0
18	183.7	0.0	183.7	122.3		306.0
19	137.2	0.0	137.2	122.3		259.5
20	113.3	0.0	113.3	122.3		235.6
21	94.3	0.0	94.3	122.3		216.6
22	78.5	0.0	78.5	122.3		200.8
23	68.3	0.0	68.3	122.3		190.6
24	61.3	0.0	61.3	122.3		183.6
TOTALS	3,162.0	1,835.2	1,326.8	1,835.2	MAX =	306.0

NOVEMBER

Hour	Cooling Load (Ton-Hrs)	On Peak (Ton-Hrs)	Off Peak (Ton-Hrs)	Required Storage (Ton-Hrs)		Required Chiller (Tons)
1	55.8	0.0	55.8	106.3		162.1
2	53.1	0.0	53.1	106.3		159.4
3	51.1	0.0	51.1	106.3		157.4
4	48.3	0.0	48.3	106.3		154.6
5	47.2	0.0	47.2	106.3		153.5
6	46.9	0.0	46.9	106.3		153.2
7	67.0	0.0	67.0	106.3		173.3
8	104.9	0.0	104.9	106.3		211.2
9	114.0	114.0	0.0			0.0
10	125.7	125.7	0.0			0.0
11	145.8	145.8	0.0			0.0
12	173.7	173.7	0.0			0.0
13	194.3	194.3	0.0			0.0
14	208.5	208.5	0.0			0.0
15	216.0	216.0	0.0			0.0
16	214.2	214.2	0.0			0.0
17	201.6	201.6	0.0			0.0
18	192.8	0.0	192.8	106.3		299.1
19	136.8	0.0	136.8	106.3		243.1
20	87.5	0.0	87.5	106.3		193.8
21	75.3	0.0	75.3	106.3		181.6
22	64.9	0.0	64.9	106.3		171.2
23	60.4	0.0	60.4	106.3		166.7
24	55.9	0.0	55.9	106.3		162.2
TOTALS	2,741.7	1,593.8	1,147.9	1,593.8	MAX =	299.1

8 HOUR ON-PEAK PERIOD (9 AM - 5 PM)

APRIL

Hour	Cooling Load (Ton-Hrs)	On Peak (Ton-Hrs)	Off Peak (Ton-Hrs)	Required Storage (Ton-Hrs)		Required Chiller (Tons)
1	87.2	0.0	87.2	132.91		220.1
2	81.4	0.0	81.4	132.91		214.3
3	76.6	0.0	76.6	132.91		209.5
4	71.6	0.0	71.6	132.91		204.5
5	71.4	0.0	71.4	132.91		204.3
6	102.9	0.0	102.9	132.91		235.8
7	160.6	0.0	160.6	132.91		293.5
8	186.2	0.0	186.2	132.91		319.1
9	205.4	205.4	0.0			0.0
10	213.1	213.1	0.0			0.0
11	244.5	244.5	0.0			0.0
12	266.1	266.1	0.0			0.0
13	283.6	283.6	0.0			0.0
14	298.9	298.9	0.0			0.0
15	307.9	307.9	0.0			0.0
16	307.0	307.0	0.0			0.0
17	299.6	0.0	299.6	132.91		432.5
18	245.6	0.0	245.6	132.91		378.5
19	197.1	0.0	197.1	132.91		330.0
20	184.1	0.0	184.1	132.91		317.0
21	156.0	0.0	156.0	132.91		288.9
22	135.9	0.0	135.9	132.91		268.8
23	117.8	0.0	117.8	132.91		250.7
24	107.8	0.0	107.8	132.91		240.7
TOTALS	4,408.3	2,126.5	2,281.8	2,126.5	MAX =	432.5

MAY

Hour	Cooling Load (Ton-Hrs)	On Peak (Ton-Hrs)	Off Peak (Ton-Hrs)	Required Storage (Ton-Hrs)		Required Chiller (Tons)
1	152.9	0.0	152.9	182.4		335.3
2	146.0	0.0	146.0	182.4		328.4
3	125.8	0.0	125.8	182.4		308.2
4	116.1	0.0	116.1	182.4		298.5
5	115.5	0.0	115.5	182.4		297.9
6	167.3	0.0	167.3	182.4		349.7
7	242.5	0.0	242.5	182.4		424.9
8	248.5	0.0	248.5	182.4		430.9
9	268.0	268.0	0.0			0.0
10	293.5	293.5	0.0			0.0
11	323.1	323.1	0.0			0.0
12	354.2	354.2	0.0			0.0
13	397.7	397.7	0.0			0.0
14	420.5	420.5	0.0			0.0
15	432.1	432.1	0.0			0.0
16	428.8	428.8	0.0			0.0
17	416.5	0.0	416.5	182.4		598.9
18	351.3	0.0	351.3	182.4		533.7
19	291.9	0.0	291.9	182.4		474.3
20	272.0	0.0	272.0	182.4		454.4
21	247.4	0.0	247.4	182.4		429.8
22	212.5	0.0	212.5	182.4		394.9
23	188.7	0.0	188.7	182.4		371.1
24	175.2	0.0	175.2	182.4		357.6
TOTALS	6,388.0	2,917.9	3,470.1	2,917.9	MAX =	598.9

JUNE

Hour	Cooling Load (Ton-Hrs)	On Peak (Ton-Hrs)	Off Peak (Ton-Hrs)	Required Storage (Ton-Hrs)		Required Chiller (Tons)
1	227.6	0.0	227.6	228.4		456.0
2	219.3	0.0	219.3	228.4		447.7
3	207.6	0.0	207.6	228.4		436.0
4	199.4	0.0	199.4	228.4		427.8
5	199.4	0.0	199.4	228.4		427.8
6	249.2	0.0	249.2	228.4		477.6
7	321.1	0.0	321.1	228.4		549.5
8	336.5	0.0	336.5	228.4		564.9
9	343.7	343.7	0.0			0.0
10	383.2	383.2	0.0			0.0
11	414.1	414.1	0.0			0.0
12	444.3	444.3	0.0			0.0
13	487.7	487.7	0.0			0.0
14	508.8	508.8	0.0			0.0
15	537.7	537.7	0.0			0.0
16	535.5	535.5	0.0			0.0
17	506.7	0.0	506.7	228.4		735.1
18	439.8	0.0	439.8	228.4		668.2
19	378.3	0.0	378.3	228.4		606.7
20	345.7	0.0	345.7	228.4		574.1
21	319.7	0.0	319.7	228.4		548.1
22	296.4	0.0	296.4	228.4		524.8
23	273.1	0.0	273.1	228.4		501.5
24	247.9	0.0	247.9	228.4		476.3
TOTALS	8,422.7	3,655.0	4,767.7	3,655.0	MAX =	735.1

JULY

Hour	Cooling Load (Ton-Hrs)	On Peak (Ton-Hrs)	Off Peak (Ton-Hrs)	Required Storage (Ton-Hrs)		Required Chiller (Tons)
1	254.9	0.0	254.9	240.2		495.1
2	238.8	0.0	238.8	240.2		479.0
3	229.2	0.0	229.2	240.2		469.4
4	221.5	0.0	221.5	240.2		461.7
5	222.0	0.0	222.0	240.2		462.2
6	269.6	0.0	269.6	240.2		509.8
7	344.4	0.0	344.4	240.2		584.6
8	357.7	0.0	357.7	240.2		597.9
9	378.6	378.6	0.0			0.0
10	401.4	401.4	0.0			0.0
11	428.0	428.0	0.0			0.0
12	473.6	473.6	0.0			0.0
13	516.2	516.2	0.0			0.0
14	537.3	537.3	0.0			0.0
15	560.6	560.6	0.0			0.0
16	546.8	546.8	0.0			0.0
17	534.4	0.0	534.4	240.2		774.6
18	467.6	0.0	467.6	240.2		707.8
19	390.6	0.0	390.6	240.2		630.8
20	372.5	0.0	372.5	240.2		612.7
21	335.7	0.0	335.7	240.2		575.9
22	311.2	0.0	311.2	240.2		551.4
23	290.3	0.0	290.3	240.2		530.5
24	264.7	0.0	264.7	240.2		504.9
TOTALS	8,947.6	3,842.5	5,105.1	3,842.5	MAX =	774.6

AUGUST

Hour	Cooling Load (Ton-Hrs)	On Peak (Ton-Hrs)	Off Peak (Ton-Hrs)	Required Storage (Ton-Hrs)		Required Chiller (Tons)
1	258.6	0.0	258.6	241.4		500.0
2	239.9	0.0	239.9	241.4		481.3
3	231.3	0.0	231.3	241.4		472.7
4	223.2	0.0	223.2	241.4		464.6
5	212.7	0.0	212.7	241.4		454.1
6	267.4	0.0	267.4	241.4		508.8
7	344.7	0.0	344.7	241.4		586.1
8	358.1	0.0	358.1	241.4		599.5
9	379.1	379.1	0.0			0.0
10	403.8	403.8	0.0			0.0
11	433.7	433.7	0.0			0.0
12	479.0	479.0	0.0			0.0
13	505.7	505.7	0.0			0.0
14	541.9	541.9	0.0			0.0
15	553.9	553.9	0.0			0.0
16	564.7	564.7	0.0			0.0
17	556.9	0.0	556.9	241.4		798.3
18	471.9	0.0	471.9	241.4		713.3
19	407.2	0.0	407.2	241.4		648.6
20	375.7	0.0	375.7	241.4		617.1
21	352.4	0.0	352.4	241.4		593.8
22	314.1	0.0	314.1	241.4		555.5
23	291.5	0.0	291.5	241.4		532.9
24	278.7	0.0	278.7	241.4		520.1
TOTALS	9,046.1	3,861.8	5,184.3	3,861.8	MAX =	798.3

SEPTEMBER

Hour	Cooling Load (Ton-Hrs)	On Peak (Ton-Hrs)	Off Peak (Ton-Hrs)	Required Storage (Ton-Hrs)		Required Chiller (Tons)
1	204.1	0.0	204.1	205.5		409.6
2	185.5	0.0	185.5	205.5		391.0
3	176.5	0.0	176.5	205.5		382.0
4	168.2	0.0	168.2	205.5		373.7
5	166.9	0.0	166.9	205.5		372.4
6	212.6	0.0	212.6	205.5		418.1
7	282.7	0.0	282.7	205.5		488.2
8	296.9	0.0	296.9	205.5		502.4
9	318.2	318.2	0.0			0.0
10	342.4	342.4	0.0			0.0
11	372.4	372.4	0.0			0.0
12	401.6	401.6	0.0			0.0
13	443.5	443.5	0.0			0.0
14	464.7	464.7	0.0			0.0
15	474.6	474.6	0.0			0.0
16	470.8	470.8	0.0			0.0
17	457.2	0.0	457.2	205.5		662.7
18	399.7	0.0	399.7	205.5		605.2
19	341.9	0.0	341.9	205.5		547.4
20	312.7	0.0	312.7	205.5		518.2
21	288.8	0.0	288.8	205.5		494.3
22	253.4	0.0	253.4	205.5		458.9
23	232.8	0.0	232.8	205.5		438.3
24	209.6	0.0	209.6	205.5		415.1
TOTALS	7,477.7	3,288.2	4,189.5	3,288.2	MAX =	662.7

OCTOBER

Hour	Cooling Load (Ton-Hrs)	On Peak (Ton-Hrs)	Off Peak (Ton-Hrs)	Required Storage (Ton-Hrs)		Required Chiller (Tons)
1	68.8	0.0	68.8	100.2		169.0
2	60.0	0.0	60.0	100.2		160.2
3	55.8	0.0	55.8	100.2		156.0
4	52.8	0.0	52.8	100.2		153.0
5	52.6	0.0	52.6	100.2		152.8
6	73.8	0.0	73.8	100.2		174.0
7	109.1	0.0	109.1	100.2		209.3
8	117.3	0.0	117.3	100.2		217.5
9	130.4	130.4	0.0			0.0
10	147.4	147.4	0.0			0.0
11	171.8	171.8	0.0			0.0
12	202.1	202.1	0.0			0.0
13	222.8	222.8	0.0			0.0
14	238.1	238.1	0.0			0.0
15	246.6	246.6	0.0			0.0
16	243.5	243.5	0.0			0.0
17	232.5	0.0	232.5	100.2		332.7
18	183.7	0.0	183.7	100.2		283.9
19	137.2	0.0	137.2	100.2		237.4
20	113.3	0.0	113.3	100.2		213.5
21	94.3	0.0	94.3	100.2		194.5
22	78.5	0.0	78.5	100.2		178.7
23	68.3	0.0	68.3	100.2		168.5
24	61.3	0.0	61.3	100.2		161.5
TOTALS	3,162.0	1,602.7	1,559.3	1,602.7	MAX =	332.7

NOVEMBER

Hour	Cooling Load (Ton-Hrs)	On Peak (Ton-Hrs)	Off Peak (Ton-Hrs)	Required Storage (Ton-Hrs)		Required Chiller (Tons)
1	55.8	0.0	55.8	87.0		142.8
2	53.1	0.0	53.1	87.0		140.1
3	51.1	0.0	51.1	87.0		138.1
4	48.3	0.0	48.3	87.0		135.3
5	47.2	0.0	47.2	87.0		134.2
6	46.9	0.0	46.9	87.0		133.9
7	67.0	0.0	67.0	87.0		154.0
8	104.9	0.0	104.9	87.0		191.9
9	114.0	114.0	0.0			0.0
10	125.7	125.7	0.0			0.0
11	145.8	145.8	0.0			0.0
12	173.7	173.7	0.0			0.0
13	194.3	194.3	0.0			0.0
14	208.5	208.5	0.0			0.0
15	216.0	216.0	0.0			0.0
16	214.2	214.2	0.0			0.0
17	201.6	0.0	201.6	87.0		288.6
18	192.8	0.0	192.8	87.0		279.8
19	136.8	0.0	136.8	87.0		223.8
20	87.5	0.0	87.5	87.0		174.5
21	75.3	0.0	75.3	87.0		162.3
22	64.9	0.0	64.9	87.0		151.9
23	60.4	0.0	60.4	87.0		147.4
24	55.9	0.0	55.9	87.0		142.9
TOTALS	2,741.7	1,392.2	1,349.5	1,392.2	MAX =	288.6

7 HOUR ON-PEAK PERIOD (10 AM - 5 PM)

APRIL

Hour	Cooling Load (Ton-Hrs)	On Peak (Ton-Hrs)	Off Peak (Ton-Hrs)	Required Storage (Ton-Hrs)		Required Chiller (Tons)
1	87.2	0.0	87.2	113.01		200.2
2	81.4	0.0	81.4	113.01		194.4
3	76.6	0.0	76.6	113.01		189.6
4	71.6	0.0	71.6	113.01		184.6
5	71.4	0.0	71.4	113.01		184.4
6	102.9	0.0	102.9	113.01		215.9
7	160.6	0.0	160.6	113.01		273.6
8	186.2	0.0	186.2	113.01		299.2
9	205.4	0.0	205.4	113.01		318.4
10	213.1	213.1	0.0			0.0
11	244.5	244.5	0.0			0.0
12	266.1	266.1	0.0			0.0
13	283.6	283.6	0.0			0.0
14	298.9	298.9	0.0			0.0
15	307.9	307.9	0.0			0.0
16	307.0	307.0	0.0			0.0
17	299.6	0.0	299.6	113.01		412.6
18	245.6	0.0	245.6	113.01		358.6
19	197.1	0.0	197.1	113.01		310.1
20	184.1	0.0	184.1	113.01		297.1
21	156.0	0.0	156.0	113.01		269.0
22	135.9	0.0	135.9	113.01		248.9
23	117.8	0.0	117.8	113.01		230.8
24	107.8	0.0	107.8	113.01		220.8
TOTALS	4,408.3	1,921.1	2,487.2	1,921.1	MAX =	412.6

MAY

Hour	Cooling Load (Ton-Hrs)	On Peak (Ton-Hrs)	Off Peak (Ton-Hrs)	Required Storage (Ton-Hrs)		Required Chiller (Tons)
1	152.9	0.0	152.9	155.9		308.8
2	146.0	0.0	146.0	155.9		301.9
3	125.8	0.0	125.8	155.9		281.7
4	116.1	0.0	116.1	155.9		272.0
5	115.5	0.0	115.5	155.9		271.4
6	167.3	0.0	167.3	155.9		323.2
7	242.5	0.0	242.5	155.9		398.4
8	248.5	0.0	248.5	155.9		404.4
9	268.0	0.0	268.0	155.9		423.9
10	293.5	293.5	0.0			0.0
11	323.1	323.1	0.0			0.0
12	354.2	354.2	0.0			0.0
13	397.7	397.7	0.0			0.0
14	420.5	420.5	0.0			0.0
15	432.1	432.1	0.0			0.0
16	426.8	426.8	0.0			0.0
17	416.5	0.0	416.5	155.9		572.4
18	351.3	0.0	351.3	155.9		507.2
19	291.9	0.0	291.9	155.9		447.8
20	272.0	0.0	272.0	155.9		427.9
21	247.4	0.0	247.4	155.9		403.3
22	212.5	0.0	212.5	155.9		368.4
23	188.7	0.0	188.7	155.9		344.6
24	175.2	0.0	175.2	155.9		331.1
TOTALS	6,388.0	2,649.9	3,738.1	2,649.9	MAX =	572.4

JUNE

Hour	Cooling Load (Ton-Hrs)	On Peak (Ton-Hrs)	Off Peak (Ton-Hrs)	Required Storage (Ton-Hrs)		Required Chiller (Tons)
1	227.6	0.0	227.6	194.8		422.4
2	219.3	0.0	219.3	194.8		414.1
3	207.6	0.0	207.6	194.8		402.4
4	199.4	0.0	199.4	194.8		394.2
5	199.4	0.0	199.4	194.8		394.2
6	249.2	0.0	249.2	194.8		444.0
7	321.1	0.0	321.1	194.8		515.9
8	336.5	0.0	336.5	194.8		531.3
9	343.7	0.0	343.7	194.8		538.5
10	383.2	383.2	0.0			0.0
11	414.1	414.1	0.0			0.0
12	444.3	444.3	0.0			0.0
13	487.7	487.7	0.0			0.0
14	508.8	508.8	0.0			0.0
15	537.7	537.7	0.0			0.0
16	535.5	535.5	0.0			0.0
17	506.7	0.0	506.7	194.8		701.5
18	439.8	0.0	439.8	194.8		634.6
19	378.3	0.0	378.3	194.8		573.1
20	345.7	0.0	345.7	194.8		540.5
21	319.7	0.0	319.7	194.8		514.5
22	296.4	0.0	296.4	194.8		491.2
23	273.1	0.0	273.1	194.8		467.9
24	247.9	0.0	247.9	194.8		442.7
TOTALS	**8,422.7**	**3,311.3**	**5,111.4**	**3,311.3**	**MAX =**	**701.5**

JULY

Hour	Cooling Load (Ton-Hrs)	On Peak (Ton-Hrs)	Off Peak (Ton-Hrs)	Required Storage (Ton-Hrs)		Required Chiller (Tons)
1	254.9	0.0	254.9	203.8		458.7
2	238.8	0.0	238.8	203.8		442.6
3	229.2	0.0	229.2	203.8		433.0
4	221.5	0.0	221.5	203.8		425.3
5	222.0	0.0	222.0	203.8		425.8
6	269.6	0.0	269.6	203.8		473.4
7	344.4	0.0	344.4	203.8		548.2
8	357.7	0.0	357.7	203.8		561.5
9	378.6	0.0	378.6	203.8		582.4
10	401.4	401.4	0.0			0.0
11	428.0	428.0	0.0			0.0
12	473.6	473.6	0.0			0.0
13	516.2	516.2	0.0			0.0
14	537.3	537.3	0.0			0.0
15	560.6	560.6	0.0			0.0
16	546.8	546.8	0.0			0.0
17	534.4	0.0	534.4	203.8		738.2
18	467.6	0.0	467.6	203.8		671.4
19	390.6	0.0	390.6	203.8		594.4
20	372.5	0.0	372.5	203.8		576.3
21	335.7	0.0	335.7	203.8		539.5
22	311.2	0.0	311.2	203.8		515.0
23	290.3	0.0	290.3	203.8		494.1
24	264.7	0.0	264.7	203.8		468.5
TOTALS	**8,947.6**	**3,463.9**	**5,483.7**	**3,463.9**	**MAX =**	**738.2**

AUGUST

Hour	Cooling Load (Ton-Hrs)	On Peak (Ton-Hrs)	Off Peak (Ton-Hrs)	Required Storage (Ton-Hrs)		Required Chiller (Tons)
1	258.6	0.0	258.6	204.9		463.5
2	239.9	0.0	239.9	204.9		444.8
3	231.3	0.0	231.3	204.9		436.2
4	223.2	0.0	223.2	204.9		428.1
5	212.7	0.0	212.7	204.9		417.6
6	267.4	0.0	267.4	204.9		472.3
7	344.7	0.0	344.7	204.9		549.6
8	358.1	0.0	358.1	204.9		563.0
9	379.1	0.0	379.1	204.9		584.0
10	403.8	403.8	0.0			0.0
11	433.7	433.7	0.0			0.0
12	479.0	479.0	0.0			0.0
13	505.7	505.7	0.0			0.0
14	541.9	541.9	0.0			0.0
15	553.9	553.9	0.0			0.0
16	564.7	564.7	0.0			0.0
17	556.9	0.0	556.9	204.9		761.8
18	471.9	0.0	471.9	204.9		676.8
19	407.2	0.0	407.2	204.9		612.1
20	375.7	0.0	375.7	204.9		580.6
21	352.4	0.0	352.4	204.9		557.3
22	314.1	0.0	314.1	204.9		519.0
23	291.5	0.0	291.5	204.9		496.4
24	278.7	0.0	278.7	204.9		483.6
TOTALS	9,046.1	3,482.7	5,563.4	3,482.7	MAX =	761.8

SEPTEMBER

Hour	Cooling Load (Ton-Hrs)	On Peak (Ton-Hrs)	Off Peak (Ton-Hrs)	Required Storage (Ton-Hrs)		Required Chiller (Tons)
1	204.1	0.0	204.1	174.7		378.8
2	185.5	0.0	185.5	174.7		360.2
3	176.5	0.0	176.5	174.7		351.2
4	168.2	0.0	168.2	174.7		342.9
5	166.9	0.0	166.9	174.7		341.6
6	212.6	0.0	212.6	174.7		387.3
7	282.7	0.0	282.7	174.7		457.4
8	296.9	0.0	296.9	174.7		471.6
9	318.2	0.0	318.2	174.7		492.9
10	342.4	342.4	0.0			0.0
11	372.4	372.4	0.0			0.0
12	401.6	401.6	0.0			0.0
13	443.5	443.5	0.0			0.0
14	464.7	464.7	0.0			0.0
15	474.6	474.6	0.0			0.0
16	470.8	470.8	0.0			0.0
17	457.2	0.0	457.2	174.7		631.9
18	399.7	0.0	399.7	174.7		574.4
19	341.9	0.0	341.9	174.7		516.6
20	312.7	0.0	312.7	174.7		487.4
21	288.8	0.0	288.8	174.7		463.5
22	253.4	0.0	253.4	174.7		428.1
23	232.8	0.0	232.8	174.7		407.5
24	209.6	0.0	209.6	174.7		384.3
TOTALS	7,477.7	2,970.0	4,507.7	2,970.0	MAX =	631.9

OCTOBER

Hour	Cooling Load (Ton-Hrs)	On Peak (Ton-Hrs)	Off Peak (Ton-Hrs)	Required Storage (Ton-Hrs)		Required Chiller (Tons)
1	68.8	0.0	68.8	86.6		155.4
2	60.0	0.0	60.0	86.6		146.6
3	55.8	0.0	55.8	86.6		142.4
4	52.8	0.0	52.8	86.6		139.4
5	52.6	0.0	52.6	86.6		139.2
6	73.8	0.0	73.8	86.6		160.4
7	109.1	0.0	109.1	86.6		195.7
8	117.3	0.0	117.3	86.6		203.9
9	130.4	0.0	130.4	86.6		217.0
10	147.4	147.4	0.0			0.0
11	171.8	171.8	0.0			0.0
12	202.1	202.1	0.0			0.0
13	222.8	222.8	0.0			0.0
14	238.1	238.1	0.0			0.0
15	246.6	246.6	0.0			0.0
16	243.5	243.5	0.0			0.0
17	232.5	0.0	232.5	86.6		319.1
18	183.7	0.0	183.7	86.6		270.3
19	137.2	0.0	137.2	86.6		223.8
20	113.3	0.0	113.3	86.6		199.9
21	94.3	0.0	94.3	86.6		180.9
22	78.5	0.0	78.5	86.6		165.1
23	68.3	0.0	68.3	86.6		154.9
24	61.3	0.0	61.3	86.6		147.9
TOTALS	3,162.0	1,472.3	1,689.7	1,472.3	MAX =	319.1

NOVEMBER

Hour	Cooling Load (Ton-Hrs)	On Peak (Ton-Hrs)	Off Peak (Ton-Hrs)	Required Storage (Ton-Hrs)		Required Chiller (Tons)
1	55.8	0.0	55.8	75.2		131.0
2	53.1	0.0	53.1	75.2		128.3
3	51.1	0.0	51.1	75.2		126.3
4	48.3	0.0	48.3	75.2		123.5
5	47.2	0.0	47.2	75.2		122.4
6	46.9	0.0	46.9	75.2		122.1
7	67.0	0.0	67.0	75.2		142.2
8	104.9	0.0	104.9	75.2		180.1
9	114.0	0.0	114.0	75.2		189.2
10	125.7	125.7	0.0			0.0
11	145.8	145.8	0.0			0.0
12	173.7	173.7	0.0			0.0
13	194.3	194.3	0.0			0.0
14	208.5	208.5	0.0			0.0
15	216.0	216.0	0.0			0.0
16	214.2	214.2	0.0			0.0
17	201.6	0.0	201.6	75.2		276.8
18	192.8	0.0	192.8	75.2		268.0
19	136.8	0.0	136.8	75.2		212.0
20	87.5	0.0	87.5	75.2		162.7
21	75.3	0.0	75.3	75.2		150.5
22	64.9	0.0	64.9	75.2		140.1
23	60.4	0.0	60.4	75.2		135.6
24	55.9	0.0	55.9	75.2		131.1
TOTALS	2,741.7	1,278.2	1,463.5	1,278.2	MAX =	276.8

6 HOUR ON-PEAK PERIOD (11 AM - 5 PM)

APRIL

Hour	Cooling Load (Ton-Hrs)	On Peak (Ton-Hrs)	Off Peak (Ton-Hrs)	Required Storage (Ton-Hrs)		Required Chiller (Tons)
1	87.2	0.0	87.2	94.89		182.1
2	81.4	0.0	81.4	94.89		176.3
3	76.6	0.0	76.6	94.89		171.5
4	71.6	0.0	71.6	94.89		166.5
5	71.4	0.0	71.4	94.89		166.3
6	102.9	0.0	102.9	94.89		197.8
7	160.6	0.0	160.6	94.89		255.5
8	186.2	0.0	186.2	94.89		281.1
9	205.4	0.0	205.4	94.89		300.3
10	213.1	0.0	213.1	94.89		308.0
11	244.5	244.5	0.0			0.0
12	266.1	266.1	0.0			0.0
13	283.6	283.6	0.0			0.0
14	298.9	298.9	0.0			0.0
15	307.9	307.9	0.0			0.0
16	307.0	307.0	0.0			0.0
17	299.6	0.0	299.6	94.89		394.5
18	245.6	0.0	245.6	94.89		340.5
19	197.1	0.0	197.1	94.89		292.0
20	184.1	0.0	184.1	94.89		279.0
21	156.0	0.0	156.0	94.89		250.9
22	135.9	0.0	135.9	94.89		230.8
23	117.8	0.0	117.8	94.89		212.7
24	107.8	0.0	107.8	94.89		202.7
TOTALS	4,408.3	1,708.0	2,700.3	1,708.0	MAX =	394.5

MAY

Hour	Cooling Load (Ton-Hrs)	On Peak (Ton-Hrs)	Off Peak (Ton-Hrs)	Required Storage (Ton-Hrs)		Required Chiller (Tons)
1	152.9	0.0	152.9	130.9		283.8
2	146.0	0.0	146.0	130.9		276.9
3	125.8	0.0	125.8	130.9		256.7
4	116.1	0.0	116.1	130.9		247.0
5	115.5	0.0	115.5	130.9		246.4
6	167.3	0.0	167.3	130.9		298.2
7	242.5	0.0	242.5	130.9		373.4
8	248.5	0.0	248.5	130.9		379.4
9	268.0	0.0	268.0	130.9		398.9
10	293.5	0.0	293.5	130.9		424.4
11	323.1	323.1	0.0			0.0
12	354.2	354.2	0.0			0.0
13	397.7	397.7	0.0			0.0
14	420.5	420.5	0.0			0.0
15	432.1	432.1	0.0			0.0
16	428.8	428.8	0.0			0.0
17	416.5	0.0	416.5	130.9		547.4
18	351.3	0.0	351.3	130.9		482.2
19	291.9	0.0	291.9	130.9		422.8
20	272.0	0.0	272.0	130.9		402.9
21	247.4	0.0	247.4	130.9		378.3
22	212.5	0.0	212.5	130.9		343.4
23	188.7	0.0	188.7	130.9		319.6
24	175.2	0.0	175.2	130.9		306.1
TOTALS	6,388.0	2,356.4	4,031.6	2,356.4	MAX =	547.4

JUNE

Hour	Cooling Load (Ton-Hrs)	On Peak (Ton-Hrs)	Off Peak (Ton-Hrs)	Required Storage (Ton-Hrs)		Required Chiller (Tons)
1	227.6	0.0	227.6	162.7		390.3
2	219.3	0.0	219.3	162.7		382.0
3	207.6	0.0	207.6	162.7		370.3
4	199.4	0.0	199.4	162.7		362.1
5	199.4	0.0	199.4	162.7		362.1
6	249.2	0.0	249.2	162.7		411.9
7	321.1	0.0	321.1	162.7		483.8
8	336.5	0.0	336.5	162.7		499.2
9	343.7	0.0	343.7	162.7		506.4
10	383.2	0.0	383.2	162.7		545.9
11	414.1	414.1	0.0			0.0
12	444.3	444.3	0.0			0.0
13	487.7	487.7	0.0			0.0
14	508.8	508.8	0.0			0.0
15	537.7	537.7	0.0			0.0
16	535.5	535.5	0.0			0.0
17	506.7	0.0	506.7	162.7		669.4
18	439.8	0.0	439.8	162.7		602.5
19	378.3	0.0	378.3	162.7		541.0
20	345.7	0.0	345.7	162.7		508.4
21	319.7	0.0	319.7	162.7		482.4
22	296.4	0.0	296.4	162.7		459.1
23	273.1	0.0	273.1	162.7		435.8
24	247.9	0.0	247.9	162.7		410.6
TOTALS	8,422.7	2,928.1	5,494.6	2,928.1	MAX =	669.4

JULY

Hour	Cooling Load (Ton-Hrs)	On Peak (Ton-Hrs)	Off Peak (Ton-Hrs)	Required Storage (Ton-Hrs)		Required Chiller (Tons)
1	254.9	0.0	254.9	170.1		425.0
2	238.8	0.0	238.8	170.1		408.9
3	229.2	0.0	229.2	170.1		399.3
4	221.5	0.0	221.5	170.1		391.6
5	222.0	0.0	222.0	170.1		392.1
6	269.6	0.0	269.6	170.1		439.7
7	344.4	0.0	344.4	170.1		514.5
8	357.7	0.0	357.7	170.1		527.8
9	378.6	0.0	378.6	170.1		548.7
10	401.4	0.0	401.4	170.1		571.5
11	428.0	428.0	0.0			0.0
12	473.6	473.6	0.0			0.0
13	516.2	516.2	0.0			0.0
14	537.3	537.3	0.0			0.0
15	560.6	560.6	0.0			0.0
16	546.8	546.8	0.0			0.0
17	534.4	0.0	534.4	170.1		704.5
18	467.6	0.0	467.6	170.1		637.7
19	390.6	0.0	390.6	170.1		560.7
20	372.5	0.0	372.5	170.1		542.6
21	335.7	0.0	335.7	170.1		505.8
22	311.2	0.0	311.2	170.1		481.3
23	290.3	0.0	290.3	170.1		460.4
24	264.7	0.0	264.7	170.1		434.8
TOTALS	8,947.6	3,062.5	5,885.1	3,062.5	MAX =	704.5

AUGUST

Hour	Cooling Load (Ton-Hrs)	On Peak (Ton-Hrs)	Off Peak (Ton-Hrs)	Required Storage (Ton-Hrs)		Required Chiller (Tons)
1	258.6	0.0	258.6	171.1		429.7
2	239.9	0.0	239.9	171.1		411.0
3	231.3	0.0	231.3	171.1		402.4
4	223.2	0.0	223.2	171.1		394.3
5	212.7	0.0	212.7	171.1		383.8
6	267.4	0.0	267.4	171.1		438.5
7	344.7	0.0	344.7	171.1		515.8
8	358.1	0.0	358.1	171.1		529.2
9	379.1	0.0	379.1	171.1		550.2
10	403.8	0.0	403.8	171.1		574.9
11	433.7	433.7	0.0			0.0
12	479.0	479.0	0.0			0.0
13	505.7	505.7	0.0			0.0
14	541.9	541.9	0.0			0.0
15	553.9	553.9	0.0			0.0
16	564.7	564.7	0.0			0.0
17	556.9	0.0	556.9	171.1		728.0
18	471.9	0.0	471.9	171.1		643.0
19	407.2	0.0	407.2	171.1		578.3
20	375.7	0.0	375.7	171.1		546.8
21	352.4	0.0	352.4	171.1		523.5
22	314.1	0.0	314.1	171.1		485.2
23	291.5	0.0	291.5	171.1		462.6
24	278.7	0.0	278.7	171.1		449.8
TOTALS	**9,046.1**	**3,078.9**	**5,967.2**	**3,078.9**	**MAX =**	**728.0**

SEPTEMBER

Hour	Cooling Load (Ton-Hrs)	On Peak (Ton-Hrs)	Off Peak (Ton-Hrs)	Required Storage (Ton-Hrs)		Required Chiller (Tons)
1	204.1	0.0	204.1	146.0		350.1
2	185.5	0.0	185.5	146.0		331.5
3	176.5	0.0	176.5	146.0		322.5
4	168.2	0.0	168.2	146.0		314.2
5	166.9	0.0	166.9	146.0		312.9
6	212.6	0.0	212.6	146.0		358.6
7	282.7	0.0	282.7	146.0		428.7
8	296.9	0.0	296.9	146.0		442.9
9	318.2	0.0	318.2	146.0		464.2
10	342.4	0.0	342.4	146.0		488.4
11	372.4	372.4	0.0			0.0
12	401.6	401.6	0.0			0.0
13	443.5	443.5	0.0			0.0
14	464.7	464.7	0.0			0.0
15	474.6	474.6	0.0			0.0
16	470.8	470.8	0.0			0.0
17	457.2	0.0	457.2	146.0		603.2
18	399.7	0.0	399.7	146.0		545.7
19	341.9	0.0	341.9	146.0		487.9
20	312.7	0.0	312.7	146.0		458.7
21	288.8	0.0	288.8	146.0		434.8
22	253.4	0.0	253.4	146.0		399.4
23	232.8	0.0	232.8	146.0		378.8
24	209.6	0.0	209.6	146.0		355.6
TOTALS	**7,477.7**	**2,627.6**	**4,850.1**	**2,627.6**	**MAX =**	**603.2**

OCTOBER

Hour	Cooling Load (Ton-Hrs)	On Peak (Ton-Hrs)	Off Peak (Ton-Hrs)	Required Storage (Ton-Hrs)		Required Chiller (Tons)
1	68.8	0.0	68.8	73.6		142.4
2	60.0	0.0	60.0	73.6		133.6
3	55.8	0.0	55.8	73.6		129.4
4	52.8	0.0	52.8	73.6		126.4
5	52.6	0.0	52.6	73.6		126.2
6	73.8	0.0	73.8	73.6		147.4
7	109.1	0.0	109.1	73.6		182.7
8	117.3	0.0	117.3	73.6		190.9
9	130.4	0.0	130.4	73.6		204.0
10	147.4	0.0	147.4	73.6		221.0
11	171.8	171.8	0.0			0.0
12	202.1	202.1	0.0			0.0
13	222.8	222.8	0.0			0.0
14	238.1	238.1	0.0			0.0
15	246.6	246.6	0.0			0.0
16	243.5	243.5	0.0			0.0
17	232.5	0.0	232.5	73.6		306.1
18	183.7	0.0	183.7	73.6		257.3
19	137.2	0.0	137.2	73.6		210.8
20	113.3	0.0	113.3	73.6		186.9
21	94.3	0.0	94.3	73.6		167.9
22	78.5	0.0	78.5	73.6		152.1
23	68.3	0.0	68.3	73.6		141.9
24	61.3	0.0	61.3	73.6		134.9
TOTALS	3,162.0	1,324.9	1,837.1	1,324.9	MAX =	306.1

NOVEMBER

Hour	Cooling Load (Ton-Hrs)	On Peak (Ton-Hrs)	Off Peak (Ton-Hrs)	Required Storage (Ton-Hrs)		Required Chiller (Tons)
1	55.8	0.0	55.8	64.0		119.8
2	53.1	0.0	53.1	64.0		117.1
3	51.1	0.0	51.1	64.0		115.1
4	48.3	0.0	48.3	64.0		112.3
5	47.2	0.0	47.2	64.0		111.2
6	46.9	0.0	46.9	64.0		110.9
7	67.0	0.0	67.0	64.0		131.0
8	104.9	0.0	104.9	64.0		168.9
9	114.0	0.0	114.0	64.0		178.0
10	125.7	0.0	125.7	64.0		189.7
11	145.8	145.8	0.0			0.0
12	173.7	173.7	0.0			0.0
13	194.3	194.3	0.0			0.0
14	208.5	208.5	0.0			0.0
15	216.0	216.0	0.0			0.0
16	214.2	214.2	0.0			0.0
17	201.6	0.0	201.6	64.0		265.6
18	192.8	0.0	192.8	64.0		256.8
19	136.8	0.0	136.8	64.0		200.8
20	87.5	0.0	87.5	64.0		151.5
21	75.3	0.0	75.3	64.0		139.3
22	64.9	0.0	64.9	64.0		128.9
23	60.4	0.0	60.4	64.0		124.4
24	55.9	0.0	55.9	64.0		119.9
TOTALS	2,741.7	1,152.5	1,589.2	1,152.5	MAX =	265.6

APPENDIX 4G

TRANE TRACE OUTPUT FOR CHILLER OPERATING KW

EQUIPMENT ENERGY CONSUMPTION - ALTERNATIVE 1
BASELINE MODEL

---------------------------------- E Q U I P M E N T   E N E R G Y   C O N S U M P T I O N ----------------------------------

Ref Num	Equip Code	Jan	Feb	Mar	Apr	May	June	July	Aug	Sep	Oct	Nov	Dec	Total
		Monthly Consumption												
0	LIGHTS													
	ELEC	97029	87721	101425	93220	99227	97590	94858	101425	93220	99227	93168	94858	1,152,968
	PK	279.4	279.4	279.4	279.4	279.4	279.4	279.4	279.4	279.4	279.4	279.4	279.4	279.4
1	MISC LD													
	ELEC	6095	5513	6246	5890	6170	6027	6034	6246	5890	6170	5861	6034	72,176
	PK	14.7	14.7	14.7	14.7	14.7	14.7	14.7	14.7	14.7	14.7	14.7	14.7	14.7
2	MISC LD													
	GAS	0	0	0	0	0	0	0	0	0	0	0	0	0
	PK	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
3	MISC LD													
	OIL	0	0	0	0	0	0	0	0	0	0	0	0	0
	PK	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
4	MISC LD													
	P STEAM	0	0	0	0	0	0	0	0	0	0	0	0	0
	PK	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
5	MISC LD													
	P HOTH2O	0	0	0	0	0	0	0	0	0	0	0	0	0
	PK	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
6	MISC LD													
	P CHILL	0	0	0	0	0	0	0	0	0	0	0	0	0
	PK	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1			BASE UTILITY											
	ELEC	37200	33600	37200	36000	37200	36000	37200	37200	36000	37200	36000	37200	438,000
	PK	50.0	50.0	50.0	50.0	50.0	50.0	50.0	50.0	50.0	50.0	50.0	50.0	50.0
2			BASE UTILITY											
	HOTLD	1284	1160	1284	1243	1284	1243	1284	1284	1243	1284	1243	1284	15,123
	PK	1.7	1.7	1.7	1.7	1.7	1.7	1.7	1.7	1.7	1.7	1.7	1.7	1.7
1	EQ1008L		3-STG CTV >200 TONS											
	ELEC	35635	31748	45542	75875	61511	60038	66725	68388	54813	54626	45044	37962	637,905
	PK	86.7	88.3	156.5	176.6	177.5	190.3	194.6	193.8	179.4	168.6	155.0	108.7	194.6
1	EQ5100		COOLING TOWER											
	ELEC	7295	4278	12186	14317	10480	7755	8014	8014	8352	14795	13435	9854	118,775
	PK	19.9	19.9	19.9	19.9	19.9	19.9	19.9	19.9	19.9	19.9	19.9	19.9	19.9
1	EQ5100		COOLING TOWER											
	WATER	184	163	247	401	322	301	329	335	282	296	242	200	3,303
	PK	0.5	0.5	0.8	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.8	0.6	0.9

EQUIPMENT ENERGY CONSUMPTION - ALTERNATIVE 1
BASELINE MODEL

1	EQ5001	CHILLED WATER PUMP C.V.												
	ELEC	36987	33407	36987	35794	26199	19388	20035	20035	20880	36987	35794	36987	359,478
	PK	49.7	49.7	49.7	49.7	49.7	49.7	49.7	49.7	49.7	49.7	49.7	49.7	49.7
1	EQ5010	CONDENSER WATER PUMP C.V.												
	ELEC	14795	13363	14795	14317	10480	7755	8014	8014	8352	14795	14317	14795	143,791
	PK	19.9	19.9	19.9	19.9	19.9	19.9	19.9	19.9	19.9	19.9	19.9	19.9	19.9
1	EQ5300	CONTROL PANEL & INTERLOCK												
	ELEC	744	672	744	720	527	390	403	403	420	744	720	744	7,231
	PK	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
2	EQ1008L	3-STG CTV >200 TONS												
	ELEC	0	0	0	4941	45683	82744	89876	93612	67028	0	0	0	383,883
	PK	0.0	0.0	0.0	187.9	232.0	246.9	251.7	253.0	239.8	139.5	0.0	0.0	253.0
2	EQ5100	COOLING TOWER												
	ELEC	0	0	0	3480	7258	11434	12329	12901	10191	0	0	0	57,593
	PK	0.0	0.0	0.0	24.9	24.9	24.9	24.9	24.9	24.9	24.9	0.0	0.0	24.9
2	EQ5100	COOLING TOWER												
	WATER	0	0	0	20	269	461	495	512	382	0	0	0	2,139
	PK	0.0	0.0	0.0	1.2	1.4	1.4	1.4	1.4	1.4	0.9	0.0	0.0	1.4
2	EQ5001	CHILLED WATER PUMP C.V.												
	ELEC	0	0	0	5568	11613	18613	19925	20641	16306	0	0	0	92,666
	PK	0.0	0.0	0.0	39.8	39.8	39.8	39.8	39.8	39.8	39.8	0.0	0.0	39.8
2	EQ5010	CONDENSER WATER PUMP C.V.												
	ELEC	0	0	0	3480	7258	11633	12453	12901	10191	0	0	0	57,916
	PK	0.0	0.0	0.0	24.9	24.9	24.9	24.9	24.9	24.9	24.9	0.0	0.0	24.9
2	EQ5300	CONTROL PANEL & INTERLOCK												
	ELEC	0	0	0	140	292	468	501	519	410	0	0	0	2,330
	PK	0.0	0.0	0.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	0.0	0.0	1.0
3	EQ1008L	3-STG CTV >200 TONS												
	ELEC	0	0	0	0	0	34	115	0	36	0	0	0	185
	PK	0.0	0.0	0.0	0.0	0.0	35.7	37.8	0.0	33.5	0.0	0.0	0.0	37.8
3	EQ5100	COOLING TOWER												
	ELEC	0	0	0	0	1750	4057	4454	4591	2088	0	0	0	17,340
	PK	0.0	0.0	0.0	0.0	19.9	19.9	19.9	19.9	19.9	0.0	0.0	0.0	19.9
3	EQ5100	COOLING TOWER												
	WATER	0	0	0	0	4	61	77	97	22	0	0	0	261
	PK	0.0	0.0	0.0	0.0	0.3	0.7	0.8	0.8	0.4	0.0	0.0	0.0	0.8
3	EQ5001	CHILLED WATER PUMP C.V.												
	ELEC	0	0	0	0	0	0	0	0	0	0	0	0	0
	PK	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
3	EQ5010	CONDENSER WATER PUMP C.V.												
	ELEC	0	0	0	0	0	398	616	0	99	0	0	0	1,114
	PK	0.0	0.0	0.0	0.0	0.0	19.9	19.9	19.9	19.9	19.9	0.0	0.0	19.9

UIPMENT ENERGY CONSUMPTION - ALTERNATIVE 1
SELINE MODEL

3 EQ5300	CONTROL PANEL & INTERLOCK												
ELEC	0	0	0	0	0	20	31	0	5	0	0	0	56
PK	0.0	0.0	0.0	0.0	0.0	1.0	1.0	1.0	1.0	1.0	0.0	0.0	1.0
1 EQ4003	FC CENTRIF. FAN C.V.												
ELEC	7142	6451	7142	6912	7142	6912	7142	7142	6912	7142	6912	7142	84,096
PK	9.6	9.6	9.6	9.6	9.6	9.6	9.6	9.6	9.6	9.6	9.6	9.6	9.6
1 EQ4003	FC CENTRIF. FAN C.V.												
ELEC	2971	2683	2971	2875	2971	2875	2971	2971	2875	2971	2875	2971	34,975
PK	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0
1 EQ4002	BI CENTRIF. FAN C.V.												
ELEC	74	67	74	72	74	72	74	74	72	74	72	74	874
PK	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
2 EQ4003	FC CENTRIF. FAN C.V.												
ELEC	16740	15120	16740	16200	16740	16200	16740	16740	16200	16740	16200	16740	197,100
PK	22.5	22.5	22.5	22.5	22.5	22.5	22.5	22.5	22.5	22.5	22.5	22.5	22.5
2 EQ4003	FC CENTRIF. FAN C.V.												
ELEC	6963	6290	6963	6739	6963	6739	6963	6963	6739	6963	6739	6963	81,989
PK	9.4	9.4	9.4	9.4	9.4	9.4	9.4	9.4	9.4	9.4	9.4	9.4	9.4
2 EQ4002	BI CENTRIF. FAN C.V.												
ELEC	74	67	74	72	74	72	74	74	72	74	72	74	872
PK	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
3 EQ4001	AIRFOIL CENTRIF. FAN C.V.												
ELEC	25817	23318	25817	24984	25817	24984	25817	25817	24984	25817	24984	25817	303,972
PK	34.7	34.7	34.7	34.7	34.7	34.7	34.7	34.7	34.7	34.7	34.7	34.7	34.7
3 EQ4002	BI CENTRIF. FAN C.V.												
ELEC	296	268	296	287	296	287	296	296	287	296	287	296	3,490
PK	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4
4 EQ4001	AIRFOIL CENTRIF. FAN C.V.												
ELEC	23659	21370	23659	22896	23659	22896	23659	23659	22896	23659	22896	23659	278,568
PK	31.8	31.8	31.8	31.8	31.8	31.8	31.8	31.8	31.8	31.8	31.8	31.8	31.8
5 EQ4003	FC CENTRIF. FAN C.V.												
ELEC	20311	18346	20311	19656	20311	19656	20311	20311	19656	20311	19656	20311	239,148
PK	27.3	27.3	27.3	27.3	27.3	27.3	27.3	27.3	27.3	27.3	27.3	27.3	27.3
5 EQ4003	FC CENTRIF. FAN C.V.												
ELEC	9427	8515	9427	9123	9427	9123	9427	9427	9123	9427	9123	9427	111,001
PK	12.7	12.7	12.7	12.7	12.7	12.7	12.7	12.7	12.7	12.7	12.7	12.7	12.7
5 EQ4002	BI CENTRIF. FAN C.V.												
ELEC	2470	2231	2470	2390	2470	2390	2470	2470	2390	2470	2390	2470	29,081
PK	3.3	3.3	3.3	3.3	3.3	3.3	3.3	3.3	3.3	3.3	3.3	3.3	3.3
6 EQ4003	FC CENTRIF. FAN C.V.												
ELEC	7589	6854	7589	7344	7589	7344	7589	7589	7344	7589	7344	7589	89,352
PK	10.2	10.2	10.2	10.2	10.2	10.2	10.2	10.2	10.2	10.2	10.2	10.2	10.2

EQUIPMENT ENERGY CONSUMPTION - ALTERNATIVE 1
BASELINE MODEL

6	EQ4003	FC CENTRIF. FAN C.V.												
	ELEC	1785	1612	1785	1727	1785	1727	1785	1785	1727	1785	1727	1785	21,012
	PK	2.4	2.4	2.4	2.4	2.4	2.4	2.4	2.4	2.4	2.4	2.4	2.4	2.4
6	EQ4002	BI CENTRIF. FAN C.V.												
	ELEC	3494	3156	3494	3382	3494	3382	3494	3494	3382	3494	3382	3494	41,142
	PK	4.7	4.7	4.7	4.7	4.7	4.7	4.7	4.7	4.7	4.7	4.7	4.7	4.7
7	EQ4003	FC CENTRIF. FAN C.V.												
	ELEC	32066	28963	32066	31032	32066	31032	32066	32066	31032	32066	31032	32066	377,556
	PK	43.1	43.1	43.1	43.1	43.1	43.1	43.1	43.1	43.1	43.1	43.1	43.1	43.1
7	EQ4003	FC CENTRIF. FAN C.V.												
	ELEC	10025	9054	10025	9701	10025	9701	10025	10025	9701	10025	9701	10024	118,030
	PK	13.5	13.5	13.5	13.5	13.5	13.5	13.5	13.5	13.5	13.5	13.5	13.5	13.5
7	EQ4002	BI CENTRIF. FAN C.V.												
	ELEC	2805	2534	2805	2715	2805	2715	2805	2805	2715	2805	2715	2805	33,030
	PK	3.8	3.8	3.8	3.8	3.8	3.8	3.8	3.8	3.8	3.8	3.8	3.8	3.8
8	EQ4003	FC CENTRIF. FAN C.V.												
	ELEC	19344	17472	19344	18720	19344	18720	19344	19344	18720	19344	18720	19344	227,760
	PK	26.0	26.0	26.0	26.0	26.0	26.0	26.0	26.0	26.0	26.0	26.0	26.0	26.0
8	EQ4003	FC CENTRIF. FAN C.V.												
	ELEC	6016	5434	6016	5822	6016	5822	6016	6016	5822	6016	5822	6016	70,831
	PK	8.1	8.1	8.1	8.1	8.1	8.1	8.1	8.1	8.1	8.1	8.1	8.1	8.1
8	EQ4002	BI CENTRIF. FAN C.V.												
	ELEC	1695	1531	1695	1640	1695	1640	1695	1695	1640	1695	1640	1695	19,957
	PK	2.3	2.3	2.3	2.3	2.3	2.3	2.3	2.3	2.3	2.3	2.3	2.3	2.3
1	EQ2004	GAS WATER TUBE STEAM												
	GAS	16459	15400	9170	4243	3322	2744	2870	2904	2896	7126	8576	13262	88,973
	PK	34.5	36.7	25.1	13.5	8.9	5.8	5.6	5.5	6.9	22.0	24.8	31.9	36.7
1	EQ5020	HEAT WATER CIRC. PUMP C.V.												
	ELEC	1981	1789	1981	1917	1981	1917	1981	1981	1917	1981	1917	1981	23,326
	PK	2.7	2.7	2.7	2.7	2.7	2.7	2.7	2.7	2.7	2.7	2.7	2.7	2.7
1	EQ5240	BOILER FORCED DRAFT FAN												
	ELEC	4307	3890	4307	4168	4307	4168	4307	4307	4168	4307	4168	4307	50,710
	PK	5.8	5.8	5.8	5.8	5.8	5.8	5.8	5.8	5.8	5.8	5.8	5.8	5.8
1	EQ5307	BOILER CONTROLS												
	ELEC	372	336	372	360	372	360	372	372	360	372	360	372	4,380
	PK	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
1	EQ5062	CONDENSATE RETURN PUMP												
	ELEC	2024	1828	2024	1959	2024	1959	2024	2024	1959	2024	1959	2024	23,834
	PK	2.7	2.7	2.7	2.7	2.7	2.7	2.7	2.7	2.7	2.7	2.7	2.7	2.7
1	EQ5406	MAKE-UP WATER												
	WATER	22	20	22	22	22	22	22	22	22	22	22	22	263
	PK	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

EQUIPMENT ENERGY CONSUMPTION - ALTERNATIVE 1
BASELINE MODEL

2	EQ2004	GAS WATER TUBE STEAM												
	GAS	0	0	0	0	0	0	0	0	0	0	0	0	0
	PK	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2	EQ5020	HEAT WATER CIRC. PUMP C.V.												
	ELEC	0	0	0	0	0	0	0	0	0	0	0	0	0
	PK	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2	EQ5240	BOILER FORCED DRAFT FAN												
	ELEC	0	0	0	0	0	0	0	0	0	0	0	0	0
	PK	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2	EQ5307	BOILER CONTROLS												
	ELEC	0	0	0	0	0	0	0	0	0	0	0	0	0
	PK	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2	EQ5062	CONDENSATE RETURN PUMP												
	ELEC	0	0	0	0	0	0	0	0	0	0	0	0	0
	PK	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2	EQ5406	MAKE-UP WATER												
	WATER	0	0	0	0	0	0	0	0	0	0	0	0	0
	PK	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

APPENDIX 4H

CASE STUDIES AND OTHER TECHNICAL SUPPORT DATA ON STRATIFIED CHILLED WATER STORAGE

November , 1992

CHILLED WATER STORAGE

E. Ian Mackie P. Eng.
Mackie Associates

INTRODUCTION

Chilled water storage; operating with only a sensible heat exchange, requiring a large storage volume, and totally dependent on secondary coolant temperature differentials can be the most cost and energy effective of the current cooling storage technologies. In both new and existing systems, chilled water storage can achieve the primary aim of leveling the demand of electrically driven cooling and at the same time reduce the first cost and energy consumption.

Typical of most storage concepts, the technology of chilled water storage is being enhanced by the demand side management incentives of the electric utilities. Current technology for chilled water storage favors the use of stratified storage. Significant advances have come from research sponsored by: Electric Power Research Institute (EPRI), Construction Engineering Research Laboratory of the US Army (CERL), Oak Ridge National Laboratory (ORNL), American Society of Refrigerating and Air Conditioning Engineers (ASHRAE), and the University of New Mexico (UNM).

This presentation includes; a cursory comparison of the chilled water storage and ice storage systems, a brief history of chilled water storage, details of the design of stratified chilled water storage, information on system interface and comments on operation.

BASIC COMPARISONS TO OTHER TYPES OF STORAGE:

Operational Temperature:

The initial consideration for selecting the type of storage in a specific application is the range of operational temperature. Figure 1 illustrates the approximate discharge temperature characteristics of common cool storage systems. Significant variations in the temperature ranges occur with changes in storage discharge rates.

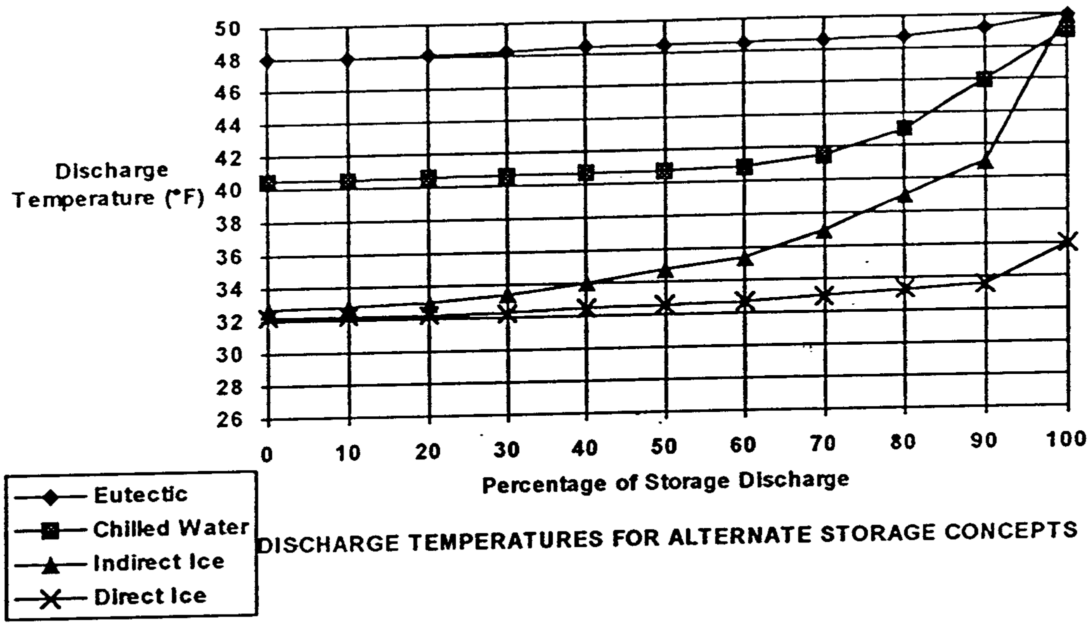


Figure 1

The curves on the graph of Figure 1 are read from left to right, with the 0% reading being the intial discharge temperature. The chilled water discharge temperature is a representation of stratified storage that operates with a 40°F charging temperature. The discharge begins slightly above the charging temperature, rising gradually to about 80% discharge. Above the 80% discharge, the temperature rises more steeply as the thermocline exits the tank.

Use of "Conventional" or existing equipment:

Chilled water storage systems use standard chillers operating at common chiller operating temperatures. Use of this conventional equipment eases design, installation, operation, maintenance, and. has the advantage of being able to utilize "idle" equipment capacity in existing installations.

Energy Consumption:

Energy consumption of chilled water storage is in the order of 10% less than conventional non storage, and 20 to 30% less than ice storage systems. The reduction from the non-storage systems is due to minimizing part load operation and to production of cooling load at night with lower wet bulb temperatures. Water chillers operate with suction temperatures of 35°F to 37°F. Ice making equipment operates with suction temperatures ranging from 15°F to 22°F. This 12°F to 15°F difference in suction temperatures affords a 20 to 30 % energy advantage for the chilled water systems.

Capital Costs:

The major element in the cost of chilled water storage is the cost of the storage tank. Tank costs depends on the amount of tank surface that is purchased to contain a given volume. The relationship between surface and volume is not linear, with much more surface and hence a greater unit cost appling to smaller tanks. The cost of tanks also vary with local labor practice and with local soil conditions.

For storage greater than 4500 ton-hours, say 500,000 gal. operating with conventional temperature differencials, the capital cost of stratified chilled water storage is approximately $50 per ton-hour. At this cost, it is possible, in new installations, to purchase partial storage systems for a lower first cost than a non storage system.

Chilled water storage applies readily to increasing the overall output of existing facilities. Where a cooling load profile has peaks and valleys, the idle capacity during the valley, charges storage. This use to increase capacity of existing plants often costs less than half of the cost of new capacity and is the most common application of water storage.

Large Volume and Dependence on Performance of Secondary Systems:

Chilled water storage requires a large volume. At conventional temperature differentials, water storage requires 12 to 16 cu. ft./ton hour. The large volumes and the dependence on the water temperature performance of secondary systems result from chilled water storage operating with only a sensible heat exchange.

Calculating stratified chilled water storage capacity involves an integration (or averaging) of the temperature difference between coincident tank leaving and entering water temperatures over the cycle of storage discharge using the following equation:

$$Q_{st} = M_w \times c \times (t_{in} - t_{out})$$

where:

Q_{st} = cooling capacity in storage

M_w = weight of the "useful" volume of water in storage

c = specific heat of water

t_{in} = temperature of the water entering the storage during discharge

t_{out} = temperature of the water exiting the storage during discharge

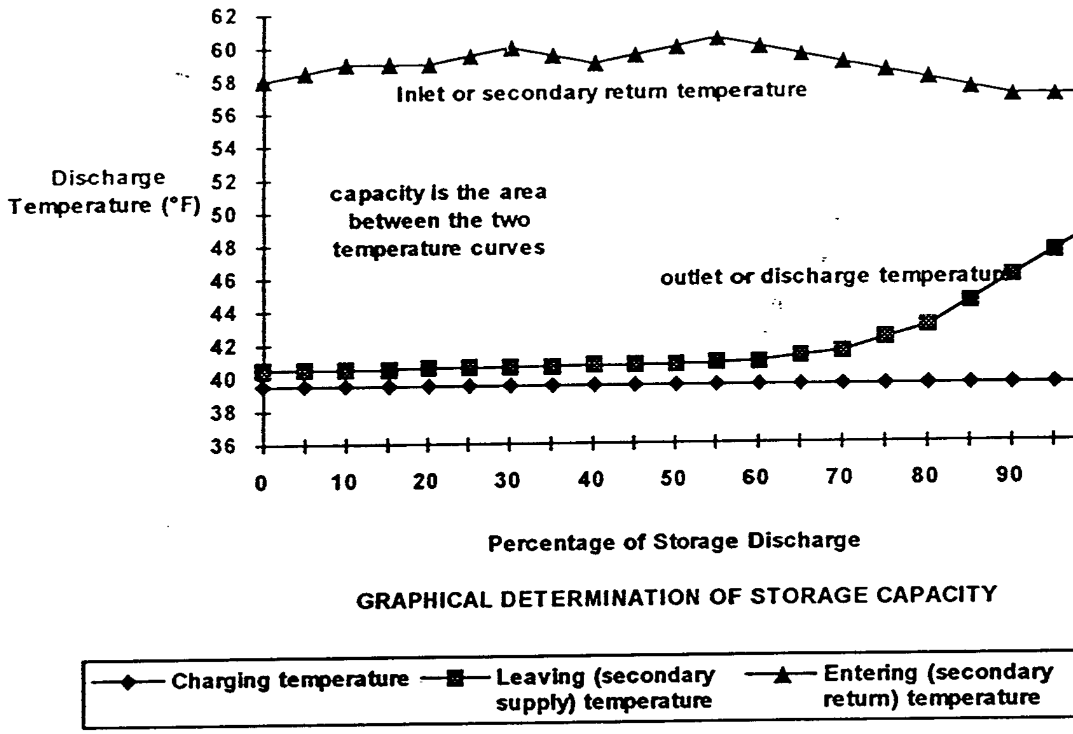


Figure 2

Capacity in the chilled water storage is the "area" between the inlet and outlet temperatures as illustrated in Figure 2. Reduction of the storage inlet temperature (secondary return) during the storage discharge, reduces the stored cooling capacity. Maintenance of the high secondary system return temperatures implies that chilled water storage systems have variable flow in secondary pumping and throttling (rather than bypass) control on the secondary coils.

DEVELOPMENT OF CHILLED WATER STORAGE:

Chilled water storage systems involve two water volumes at different temperatures: the first is a volume at low temperature to service load, the second is a volume returning from load at a warmer temperature. Mixing of these two volumes results in a loss of effective cooling storage capacity. The development of chilled water storage concepts traces the improvements is separating the two water volumes.

The measure of water storage performance is the degree of separation of the two water volumes. Ideally, the concept should limit internal energy transfer from the warm to the cold, avoid mixing, and be capable of delivery of a high percentage of the total storage volume at or near the charging temperature. Recovery of the water from storage at or near the charging temperature, maximizes the storage capacity and reduces a potential energy penalty of operating the refrigeration at too low a suction temperature.

A brief evolution of chilled water storage includes the following systems:

- -Labyrinth
- -Baffle
- -Tank Series
- -Empty Tank
- -Flexible Membrane
- -Thermal stratification

Labyrinth, Baffle and Tank Series operate with varying degrees of success, however, they are generally inefficient due to internal energy transfers.

Empty tank systems, with the cold and the warm volumes in separate tanks, provide a positive separation of the two volumes. Overall storage volume is larger than stratified systems, due to the requirement for the "empty" volume. Piping and valving are extensive, requiring coordinated control to facilitate the volume transfers.

Flexible membrane systems are the first of the stratified designs; both the warm and the cold volumes are in a single, common tank. The flexible membrane, usually a reinforced polyester, separates the warm and the cold water and moves up and down in the tank with charge and discharge. The disadvantages include: the membrane; monitoring of storage capacity, membrane maintenance, and limits to pump operation.

Current technology favors the use of naturally stratified chilled water, which separates the warm and the cold water by utilizing the natural tendency for water at different temperatures to stratify because of the density differences.

Stratified storage uses a single tank for the two operational volumes affording simple operation, effective utilization of the total water volume and low capital cost. Properly designed and operated stratified chilled water systems will yield up to 70 % of the total tank volume within 1.5°F of the charging temperature and in excess of 90 % of the total tank volume within 5°F of the charging temperature.

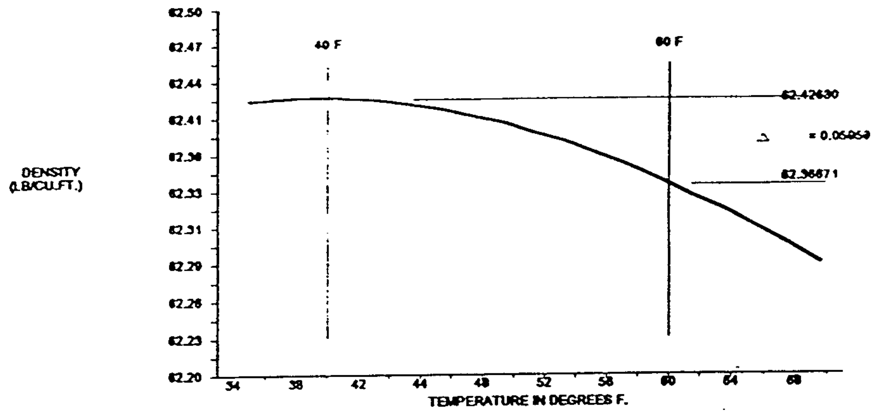
A 1985, EPRI sponsored research project at the University of New Mexico is the major event leading to the current stratified storage technology. (EPRI Report EM-5432 Vols. 1 & 2) This initial investigation, and subsequent investigations define conservative calculations for stratified storage design.

THERMALLY STRATIFIED STORAGE SYSTEMS:

Thermally stratified storage systems operate by storing cold water ***below*** warm water in a single tank. The concept uses the ***natural tendency of water to stratify*** in horizontal layers according to temperature. (density) Almost any tank containing both chilled water and warmer water will naturally, reliably stratify. If stored water consists of horizontal planes of temperature that increase in an upward direction, buoyant forces maintain stratification. If temperature decreases in an upward direction, with warm water below cold water, buoyant forces produce vertical fluid motion causing mixing.

Water Density Varies with Temperature:

The density of water increases with reducing temperature down to a limit of 39.2°F (See Figure 3 and tables reference 1). Below 39.2°F, water density decreases with a further reduction in temperature.

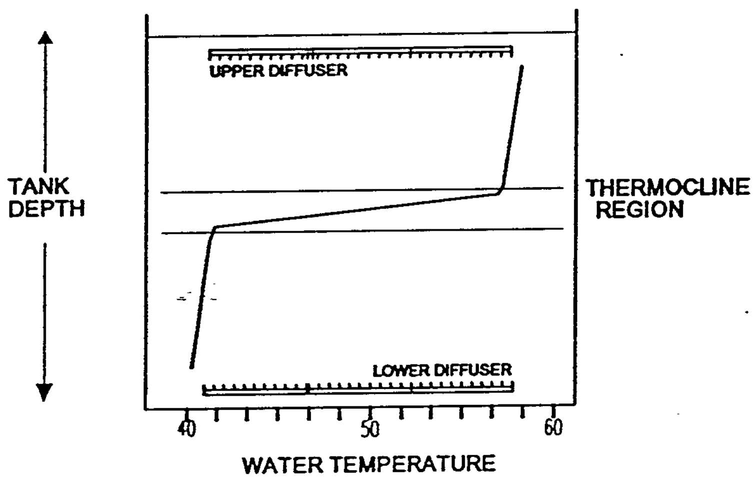


WATER DENSITY VARIATION WITH TEMPERATURE

Figure 3

Thermocline:

If the temperatures are controlled, and the ***colder water is properly introduced into the bottom*** of a tank of warm water, the water in the tank will stratify creating a region of vertical temperature difference called a ***thermocline*** as shown in Fig. 4



CONCEPT OF STRATIFIED STORAGE

Figure 4

The thermocline is a relatively thin horizontal layer in which the temperature and density gradients are much larger than in the rest of the tank. The thermocline acts as a physical boundary between the cold and the warm water. In operation of stratified storage, there is a reversal of the flow through the tank. The thermocline shifts upward during charging(bottom inlet) and downward during discharging (top inlet).

Internal Heat Transfer:

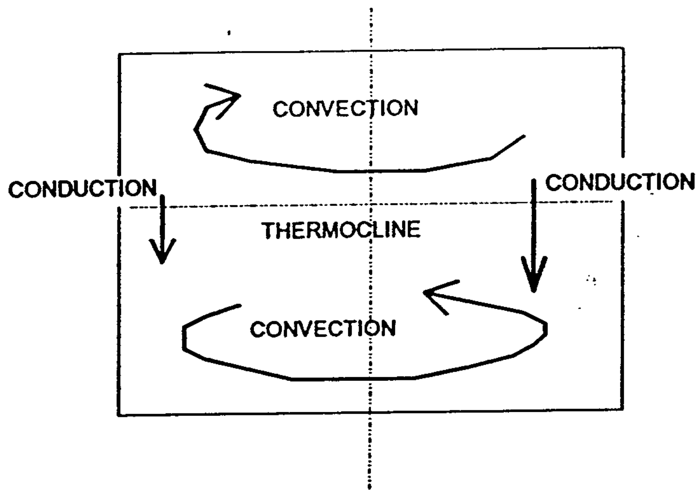


Figure 5

There are two mechanisms that will move heat from the warm water to the cold water in a stratified tank, conduction and convection as illustrated in the diagram of Figure 5. With the cold and the warm water is contact there is conduction, however, water is a poor conductor and the internal heat transfer due to conduction alone is nor major. Storing the cold (more dense) water below the warm (less dense) water, eliminates density currents and free convection. Charging involves injecting cold water into the bottom of the tank. Discharging involves injecting warm water into the top of the tank. The injection, if not properly controlled, causes forced convection, which, in the extreme could thoroughly mix the tank. The primary criterion, therefore, in the design of a stratified storage system is control of forced convection.

Diffusers:

There are two diffusers, one in the top and one in the bottom, that introduce and withdraw water, creating and maintaining thermoclines. The upper diffuser creates a thermocline at the top of the tank during the discharge cycle. The lower diffuser creates a thermocline at the bottom of the tank during the charge cycle.

Mixing in the tank increases with increasing velocity of the incoming stream and decreases with increases in the density difference. If the incoming water is a "jet-like" flow, the inertial and the shear forces will completely mix the contents. Even distribution and limited inlet velocity allows the buoyant forces, caused by the density differences, to be dominant, resulting in stratification of the tank. With the buoyant force dominant over inertia and shear, the incoming flow creates a ***gravity current***, which propagates across the top or the bottom of the tank driven by the density difference.

Figure 6 illustrates the gravity current. Note the characteristic "head" at the front of the flow.

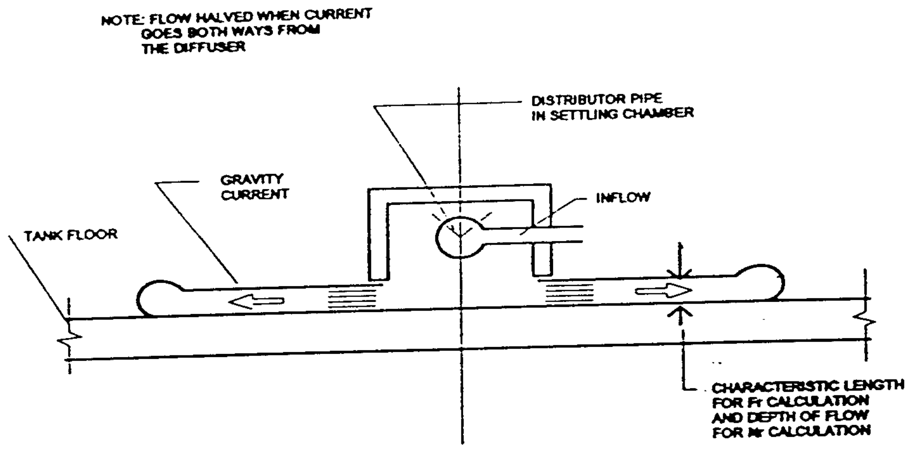


ILLUSTRATION OF A GRAVITY CURRENT

Figure 6

DESIGN OF DIFFUSERS FOR STRATIFIED STORAGE

Froude Number (Fr) and Reynolds Number (Nr):

Two dimensionless parameters for fluid flow, namely: the ***densimetric Froude Number (Fr)*** and the ***Reynolds number (Nr)*** characterizes effective diffuser design.(2,4,6,8)

The following equations define the dimensionless parameters:

$$Fr = \frac{u}{\sqrt{(gL\beta(t_w - t_c))}}$$

where:

Fr = Densimetric Froude Number

g = acceleration of gravity

u = average velocity in the density current

L = characteristic depth of the density current

β = coefficient of volumetric expansion

t_w = temperature of the ambient water

t_c = temperature of the inlet water

The L term, in theory, is the depth of the gravity current as indicated in Figure 6. The depth of the gravity current is *approximately* the height of the outlet slot of the diffuser, therefore, substitute the slot height "h" for the characteristic dimension "L". Substituting "h" for "L", the Fr is Fr_i, pertaining to the inlet, and this is a convenient design parameter.

Replacing the volumetric expansion term "β" with the ratio of the density difference, as:

$$\beta(t_w - t_c) = \frac{(\rho_i - \rho_a)}{\rho_a}$$

where:

ρ_a = density of the ambient fluid

ρ_i = density of the inlet fluid

and replacing the velocity term "u" by the flow per unit length of diffuser "q", using the slot height, "h" as the depth of the flow, then the equation for the inlet Froude number, Fr_i becomes:

$$Fr_i = \frac{q}{(g\frac{\Delta\rho}{\rho}h_i^3)^{1/2}}$$

A recommended value for the Fr is one. Making the substitutions and setting Fr = 1.0, the equation solves for the minimum slot height as:

$$h_{\min} = \frac{q^{2/3}}{(g(\frac{\rho_i - \rho_a}{\rho_a}))^{1/3}}$$

Note that this calculated dimension for the slot height applies to the upper diffuser (depth from the water surface) and the lower diffuser (depth from the floor).

The second dimensionless parameter, Nr, or Reynolds Number is defined as follows:

$$\mathrm{Re} = \frac{ul}{\eta}$$

where:

Re = Reynolds Number

u = average velocity in the density current

l = depth of the flow

η = kinematic viscosity

Similar to the modification of the equation for Fr, the Re equation, in terms of the flow per unit length is:

$$\mathrm{Re} = \frac{q}{\eta}$$

Discharge Temperature Characteristic Varying with Nr:

Research investigation(8) of a 35,000 gal storage tank established that the temperature differential between the charging temperature and the discharge temperature increases with increasing Nr. The graph of Figure 7 indicates the shift of the temperature characteristic with variation in Nr.

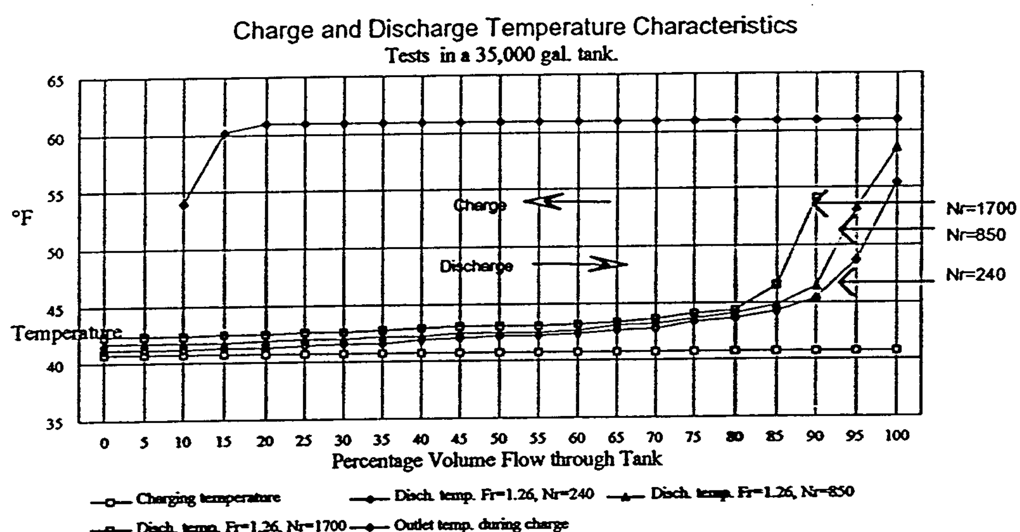


Figure 7

In Figure 7, the charging temperature, or the tank inlet temperature during charge reads from right to left and is a plot of the temperature entering the tank as the charge progresses for a 100% warm tank to a cold tank. The next three lines, indicated as "discharge temperatures", read from left to right, and are plots of the tank outlet temperatures for the three indicated Nr values. The uppermost line, indicated as "outlet temperature during charge" reads from right to left, and is a plot of the temperature leaving the top of the tank during the charging process.

Studies of initial thermocline formation determined that thermclines will form with Fr as high as 15, however there is excessive mixing immediatly outside the diffuser for values exceeding 2. Below a value of 1.0, there is not a noticeable reduction in the mixing.

Figure 7 indicates the shift in the performance of the stratified tank for increasing Nr. With higher values of Nr: the initial temperature differential between the charging temperature and the discharge temperature is greater, the thermocline exits earlier, the temperature profile rises sharply at a lower percentage of the tank volume, and the thermocline is "thicker". The shift of the temperature discharge profile affects the storage capacity of the tank by changing the overall temperature differential and by reducing the percentage of useful volume.

The required values for Nr and Fr depend, in part, on the depth of the tank. In a shallow tank, say 7 to 10 feet deep, a thin thermocline (12 to 18 inches) is desirable to maximize the useful percentage of the tank volume. In deeper tanks, say 40 feet deep and greater, a thicker thermocline is accommodated with less of a percentage of the total volume. For example, in

one successful application, a thermocline of 7 ft depth occurs in a 70 ft. deep tank. In this very deep tank, the thick thermocline only involves 10 % of the total tank volume.

Obtaining a thin thermocline requires that Fr be in the order of 1 and Nr be in the order of 450 or less. Low values of F_r are obtained by; reducing the flow per unit length, increasing the density difference and by increasing the depth of flow of the gravity current. Nr, however, is increased by increasing the depth of the flow. In combination, both the parameters are reduced by reducing the flow per unit length. For a fixed flow, the reduction in the flow per unit length is achieved by increasing the active length of the diffuser. In shallow tanks, with relatively large surface areas, increasing the active length of the diffuser is easily accomodated. In deeper tanks, with smaller surface areas it is difficult to increase the active length, however the thicker thermocline from the higher Nr values has less impact.

Flow Rate for Diffuser Design:

The diffusers are designed for the greatest flow rate that occurs over the complete cycle of the storage operation. This greatest flow rate establishes the flow per unit length for the defined parameters. The flow requirement applies to the start operations when the thermoclines are being formed and to the continued operation after the thermclines move away from the diffusers.

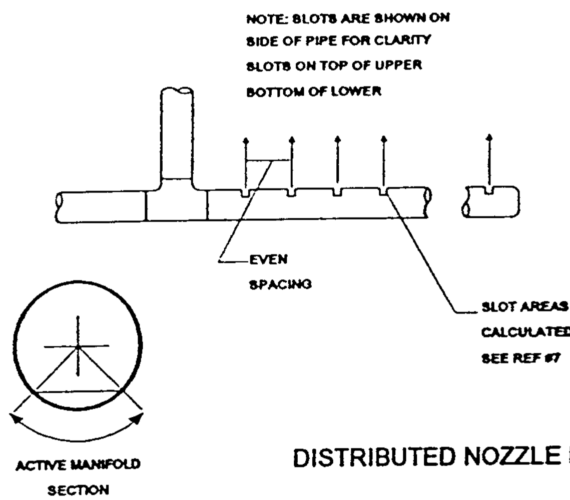
The charging operation, as described later, often involves a greater flow than the discharging operation because the charge circulates more than the total tank volume, wheras the discharge circulates less than the total volume. The discharge is usually terminated at the limiting discharge temperature. In addition, the off-peak period, used for charging, is often shorter than the on-peak period used for discharging.

A normal operating strategy, provides a constant circulation (partial storage) or no circulation (full storage) in the chiller circuit during the discharge operation. Flow variation in the secondary circuit is absorbed by the storage. In specific application, the peak flow to the secondary circuits may be the greatest flow through the diffusers. In other applications, the storage strategy involves a peak draw from the storage in a default or emergency situation, such as failure of a chiller. It is common to check this emergency flow to ensure that the tank contents will not mix at the higher parameters, but to design the diffusers for the normal flow rates.

Controlling Flow Per Unit Length - Uniform flow distribution:

Designing diffusers involves obtaining a (relatively) uniform flow over the entire length of the active diffuser. The diagram of Figure 6 illustrates a pipe in an enclosure to distribute the flow. The outer enclosure acts as a "settling chamber" which presents a continuous slot for a low velocity flow into the storage tank over the entire length of the diffuser.

The use of an inner and outer pipe arrangement for the diffuser is expensive. It is possible to eliminate the outer enclosure by limiting the velocity of the openings and avoiding the "jet like" flows. This procedure involves increasing the size of the distributor pipe, minimizing the variation in flow out of the orifices due to changes in internal header pressure because of friction and velocity pressure regain.



DISTRIBUTED NOZZLE DIFFUSER

Figure 8

The simpler, less expensive diffuser is a single manifold with evenly spaced orifices as shown in the diagram for a distributed nozzle diffuser in Figure 8. If all of the orifices are the same, having the same flow coefficient, the flow through each orifice is a function of the difference in static pressure across the offce as per the following equation:

$$Q = C_v\sqrt{\Delta p}$$

where:

$Q = flow$

$C_v = orifice\ flow\ coefficient$

$\Delta p = static\ pressure difference$

The outer static pressure is the pressure in the tank at the level of the diffuser, and is a constant. The inner static pressure is the static pressure at the location of the specific orifice in the manifold. This pressure varies down the length of the manifold depending on the friction loss and the static regain in the manifold. If the presssure drop across the orifice is high in relation to the static pressure variation down the length of the manifold, the flows out each of the orifices tend to be the same. Too high pressure drop across the orifices requires velocities through the orifices that produces "jet like" flow from the individual openings, which causes mixing in the tank. The pressure drop and the velocities through the orifices can be reduced while maintaining even flow by increasing the size of the manifold, thus reducing the pressure variations due to friction and static regain.

Flow visualization tests indicate that if the velocities out of the openings are in the order of 1 fps. and the spacing is 4 to 8 inches on centers, "jet like" flow conditions are avoided and the incoming flow will form a pool adjacent the series of openings in the manifold forming a uniform gravity current. Given the tolerance in the values of Fr and Nr that are possible for the operation of stratified storage, a reasonable variation in the flow over the length of the diffuser can be tolerated. Using the calculation procedure from reference 7 and considering the openings as evenly distributed ,square edged, laterals off a manifold, the distribution of the flow can be approximated. An example of the calculated variation in the flow down the length of a single element of a distributed nozzle diffuser is illustrated in the diagram of Figure 9.

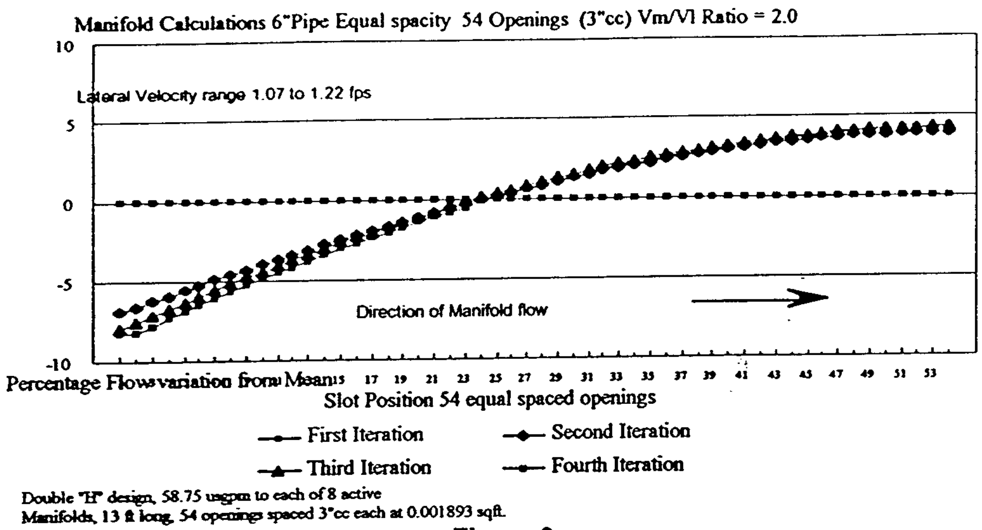


Figure 9

The example of Figure 8 indicates a variation in the flow out of the evenly spaced openings as approximately ± 5 %.

Self Balancing Headers - Diffuser Examples:

There are a variety of successful diffuser designs including: linear slot diffuser similar to Figure 6, distributed nozzle diffuser of Figure 8, radial diffuser of Figure 10, and the octagonal diffusers of Figures 11 and 12.

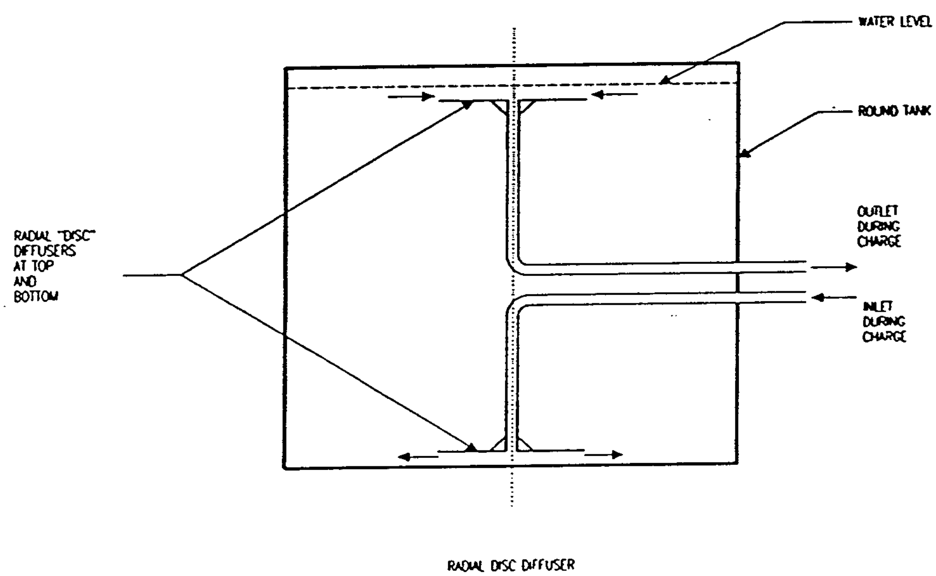


Figure 10

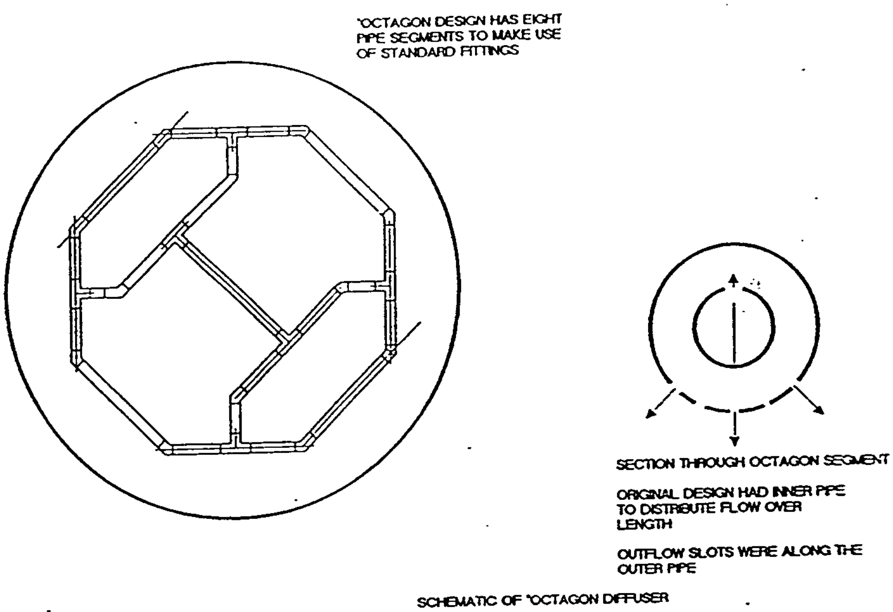
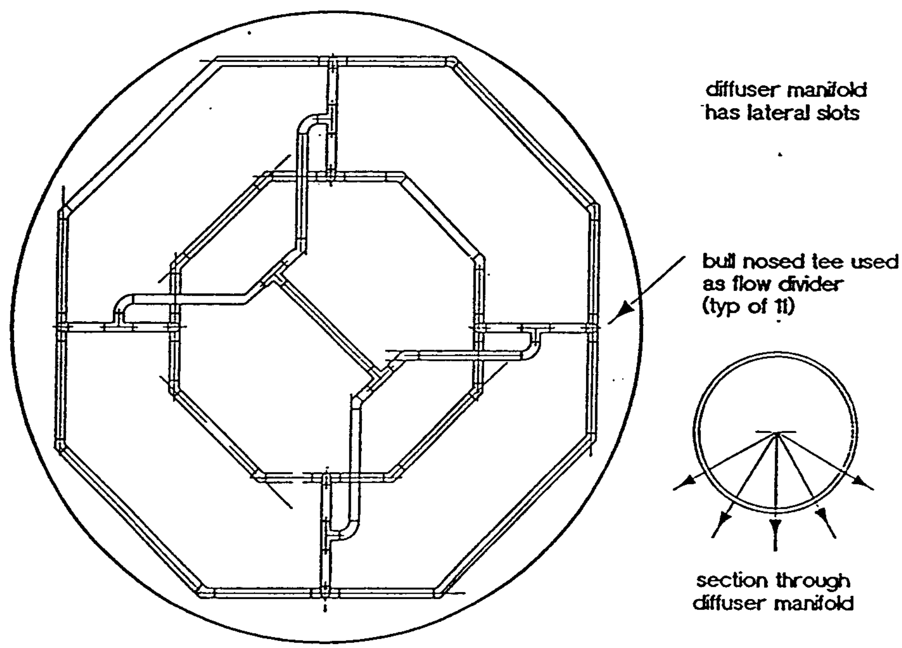


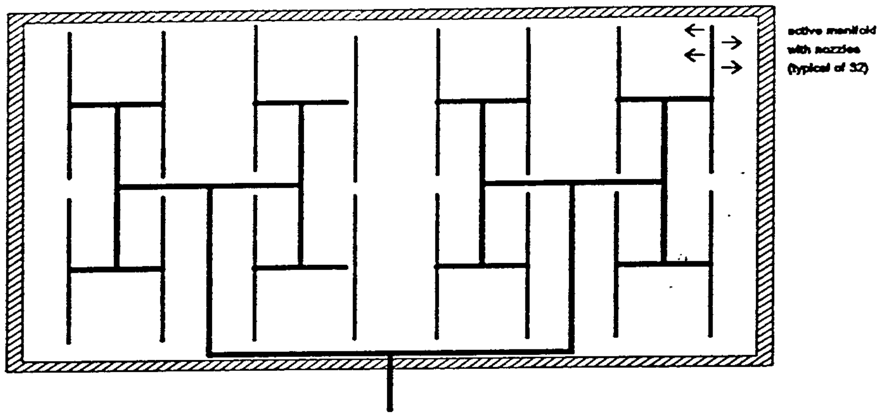
Figure 11



DOUBLE 'OCTAGON' DIFFUSER

Figure 12

Self balancing headers connect the active lengths of the diffusers in the preceding examples. Self balancing arrangements make use of "bull headed" tees with equal piping lengths to balance the flow as shown in figure 13.



SELF BALANCING HEADER

ON A "DISTRIBUTED NOZZLE" DIFFUSER SYSTEM

Figure 13

CALCULATION OF TANK VOLUME FOR STRATIFIED STORAGE:

Limiting Discharge Temperature:

Calculation of the volume of a stratified tank requires coincident temperature profiles of water leaving and entering the tank over the discharge cycle and definition of a project specific ***limiting discharge temperature***. Discharge of the storage tank continues until the discharge temperature rises to some temperature where it is above the useful cooling temperature for the specific project. This temperature is termed the ***"secondary system limiting supply temperature"***. Designers determine limiting temperatures for specific projects. In the design of systems with full storage, selection of the limiting temperature establishes the inlet water design temperature for the cooling coils since this is the temperature that the coils will receive at the end of the storage discharge. In partial storage designs, the design coil inlet temperature is a blend of the temperature of water out of the storage and water coming off the chiller. In partial storage designs, therefore, it is possible to discharge the storage to a higher limiting temperatue without having to increase the design coil inlet temperature. With the higher discharge temperature limit, a greater percentage of the storage is usually available in the partial storage systems.

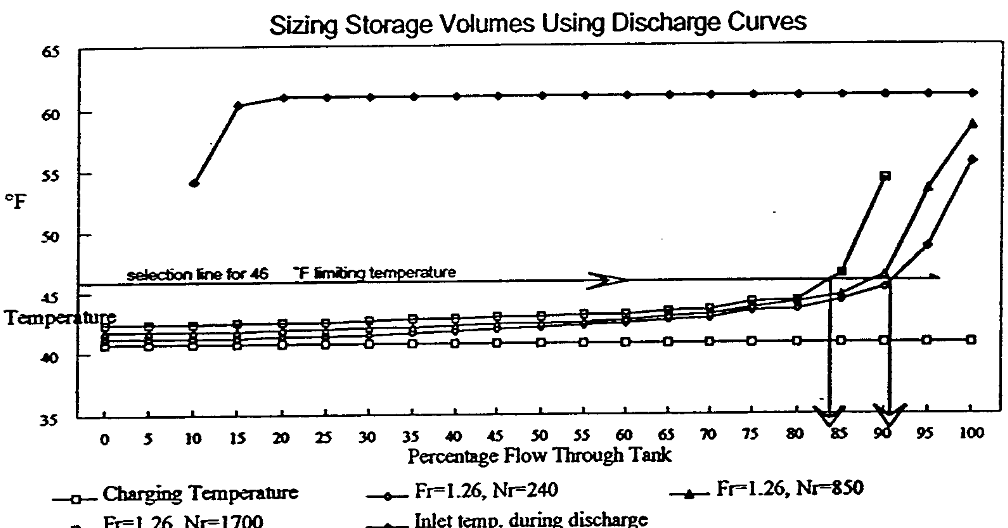


Figure 14

Figure 14 shows an example of the determination of useable storage volume using a 46°F limiting temperature. Reading across from the temperature axis, the selection is approximately 85% of the total volume for a diffuser with Nr=1700 and slightly over 90% of the total for a diffuser with Nr=240.

CHILLER CAPACITY REQUIRED TO CHARGE THE STORAGE TANK:

Chiller Inlet Temperature:

Determination of the chiller output capacity required for charging the tank, depends required charge flow rate and the temperature differential between chiller inlet and outlet temperatures. If, during the charging operation, the secondary pumps are not in operation, the inlet temperature to the chillers will be the outlet temperature from the storage. If secondary pumps are operating durign the charging operation, servicing a night load, the inlet temperature

to the chillers will be a blend of the outlet temperature from the storage and the secondary system return temperature.

At the start of the charging operation, water leaving the top of the tank will be slightly cooler than the return temperature, similar, but reversed to the storage discharge temperature characteristic, due to mixing and conduction. The outlet temperature declines gradually at first, and then more rapidly as the residual from the discharge and the top of the charging thermocline exit the top of the tank. At a given flow, the greatest temperature differential for the chiller will occur at the start of the charge operation.

Tank Flow more than 100 % of Tank Volume for "Full" Charge:

In order to completely charge the storage tank it is necessary to circulate more than the full volume of the tank, purging the thermocline. The required circulation volume depends on the specific diffuser design and is generally in the order of 110% of the tank volume. Note that if the charge cycle time and the discharge cycle time are the same, for example both at 12 hours, the flow rate through the tank is greater during the charging because 110% of the volume is handled during charge and only 90% is handled during discharge.

Chiller output is not uniform during the charging operation:

When the chiller flow and leaving temperature are fixed during the charging operation, the declining outlet temperature will cause the chiller output to decline over the charging operation. Some designs arrange to vary the flow through the chiller evaporator to moderate the influence of the declining inlet temperature.

TANK SHAPES FOR STRATIFIED STORAGE:

Testing limited to Flat Floors and Vertical Walls:

Testing for thermally stratified storage tanks is confined to tanks with flat floors and vertical walls. Tanks with continuously curving bottoms such as horizontal cylindrical tanks have not been tested. Some unpublished, private testing has been done on below grade fire tanks with sloping walls. Beyond the essential requirement for the flat floor and the vertical walls, the only other considerations are surface-to-volume ratio and the impact of depth on usable volume.

Surface to Volume Ratio:

Surface to volume ratio affects the performance of the storage tanks. The magnitude of the impact has not been quantified in either research or field testing. Without having internal tank insulation, there could be heat conduction down the walls of the tank, from the warm volume to the cold volume. This conduction could cause an "internal" heat transfer that would reduce the effective storage capacity of the tank. Although anticipated, the result is not apparent in tanks with a "reasonable" surface-to-volume ratio. Flow visualization reveals the presence of the conduction down the walls. Attempts to measure and quantify wall conduction are not conclusive because the effects are small.

Added to the potential for greater internal heat transfer, very high surface-to-volume ratios could lead to excessive losses to the surround. Similar to the potential for internal transfer, the losses to the surround tend to be small in relation to the storage capacities. Attempts to measure the losses to the surround have been generally unsuccessful, due to the relatively small temperature differentials involved and the very high levels of accuracy required to measure small losses. Some recent operational monitoring of existing installations indicates thermal losses to the surround in the order of 15% when the tanks are being used in a "full

charge" condition to service only partial loading. Monitoring of the same tanks under full or near full load conditions indicates losses to the surround are incidental.

Tank Depths:

The depth of the tank can have a significant influence on the usable or "useful" volume of the tank. Varying the depth of the tank impacts the design of the stratified tanks (diffusers) in two ways. In shallow tanks, diffuser design becomes more critical. It is necessary, in the shallow tanks, to develop a thin thermocline so that the thickness of the thermocline occupies a minimum percentage of the tank depth. In deeper tanks, with reduced plan area, the limited space available makes it difficult, or impossible, to achieve low values of Nr.

Initial mixing and conduction, even with desirable values of Fr and Nr will create thermoclines in the order of 12 inches. For a very shallow tank, say, 6 ft. in depth, the thermocline will occupy 1/6th of the depth, or 16.6 % of the tank total volume. As the depth of the tank reaches and exceeds 8 ft, the depth of the thermocline loses significance. Refer to the previous section relating to dimensionless parameters.

CHEMICAL TREATMENT:

It is essential to provide cleaning, initial, and on going chemical treatment in chilled water storage tanks. The cleaning and treatment are not unlike the treatment required for all chilled water systems. The problem is made more difficult by; the increase in volume, the presence of the (usually atmospheric) open tank, and by very low velocity circulation through the tank. For detailed information on storage water treatment, refer to the EPRI publication for treatment of water storage systems.[10]

SYSTEM ARRANGEMENT:

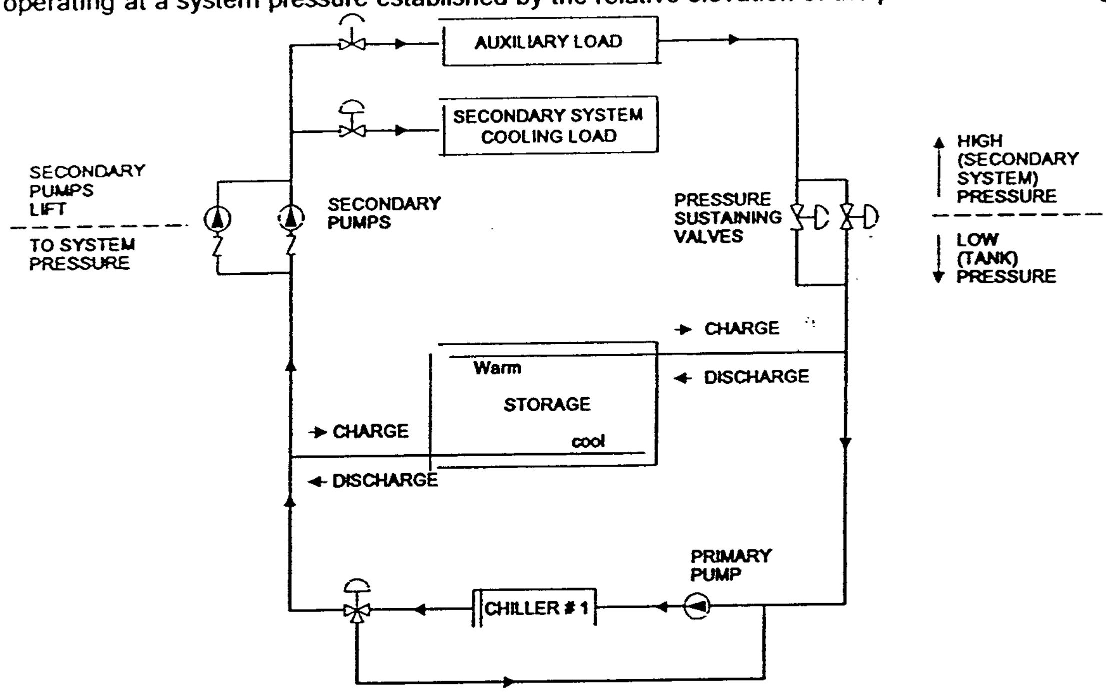
Basic configuration:

The simplified flow diagram of Fig. 15 illustrates the major components and one possible configuration of chiller and tank. With the need to maintain secondary system temperature differentials, the secondary systems use throttling control (rather than bypass control) and variable flow pumping. A parallel arrangment of the storage and the chiller with primary pump is used to maintain the flow through the chiller. Note that the connection to the supply of the secondary system is from the bottom of the storage and the return connection is to the top of the tank.

Atmospheric Plant Pressure:

Most large volume, chilled water storage tanks are atmospheric. Pressure sustaining valves maintain the operating pressure of the secondary systems. Without the use of an interface heat exchanger (not shown) the secondary pumps need to include static lift from the atmospheric tank to the operating system pressure. Heat exchangers for pressure or chemical isolation of the tank eliminates the need for the secondary pumps to handle the static lift. Adding the heat exchanger involves adding a second set of variable flow pumps to circulate through the storage. In addition, the approach temperatures required by the heat exchanger directly reducing the storage capacity of the tank by reducing the tank temperature differential.

The simplified diagram of Fig. 15 illustrates a system where the plant (chillers) is operating at a system pressure established by the relative elevation of the plant and the storage.



SCHEMATIC OF WATER STORAGE
WITH ATMOSPHERIC PLANT

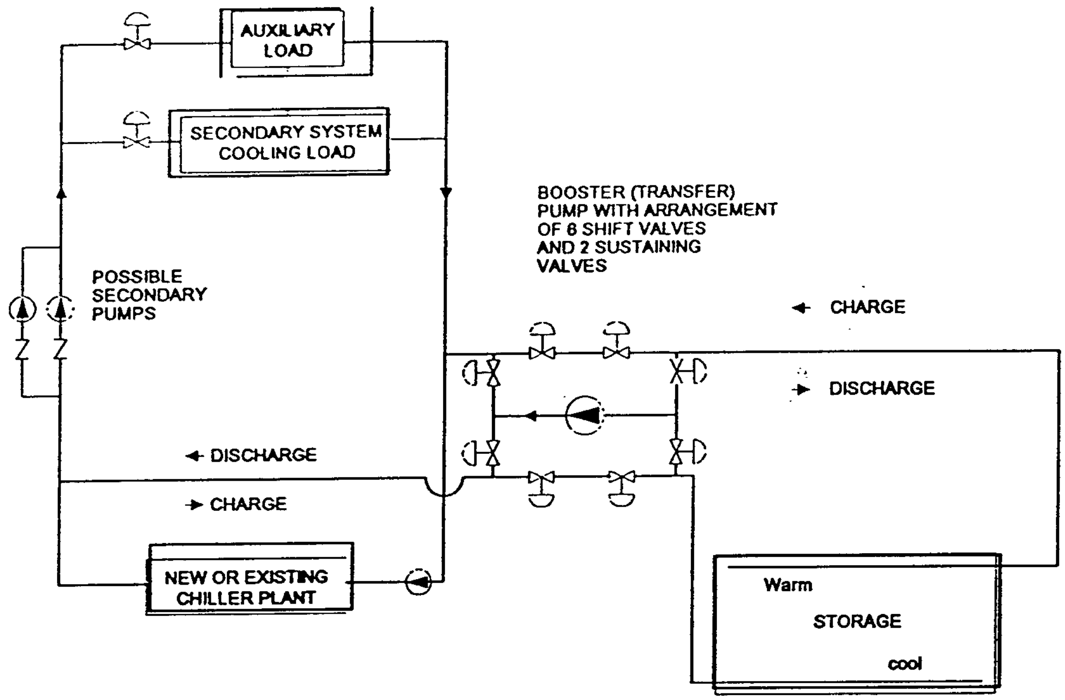
Figure 15

The advantage of this atmospheric arrangement is that the system can shift from use of the chillers to use of the tank simply by adjusting the relative flow in the primary and secondary circuits. In the discharge mode, if the chiller primary pump is off, flow through the secondary pumps is directed through the storage tank and the tank discharges to carry the building load. Starting the chiller primary pump will contribute the output of the chiller either to the secondary pumps or to the storage tank. If the flow through the secondary pumps exceeds the output flow of the chiller pumps, the chiller and the storage will share the building load (partial storage). The rate of storage discharge will depend on the difference between the flow from the chiller pump and the flow through the secondary pumps. The three way valve in the discharge line off the chiller, is one method of reducing the contribution of the primary pump to the system thus "demand limiting" the chiller output. If the flow through the chiller pumps exceeds the flow through the secondary pumps, flow through the storage tank will reverse charging the storage.

The configuration of Fig. 15 accommodates an easy shift from charge to discharge (or discharge to charge) simply by starting or stopping the chiller primary pumps.

Pressurized Plants:

The diagram of figure 16 shows a typical connection to an existing system. In this case, the plant operates at system pressure. Connection to the storage include a transfer pump and a sustaining valve.



SCHEMATIC OF STORAGE WITH
SYSTEM PRESSURE PLANT

Figure 16

The transfer pump always pumps from the low pressure tank to the high pressure system. Duplicate pumps and sustaining valves or an arrangement of isolating valves reverses the flow when the operation shifts from charging to discharging. This configuration is not as convenient as the atmospheric plant arrangement of Figure 15, since the shift from charge to discharge requires the switching of the operation of the transfer pumps and the pressure control valve.

OPERATION AND CONTROL:

Energy Management:

Cooling storage is a true energy management system that facilitates the management of the operation of cooling plant. The common primary reason for using storage is to manage the operation of the cooling plant to avoid electrical rate structure penalties with on-peak operation of the cooling plants. A secondary reason, which in the case of chilled water storage is gaining importance, is optimization of the operation of the plant to reduce energy consumption.

Initial operating concerns, primarily relating to load anticipation have not materialized. The reverse is true; storage systems are simpler to operate than non-storage systems. Storage cooling plants operate with high load factors, avoiding inefficient operation at part load. The high load factor, combined with plant operation at low evening wet bulb temperatures, results in significant reduction of cooling energy requirement. Storage operates with relatively high thermal efficiencies, and it is possible to conservatively accumulate a moderate excess of cooling capacity with little energy penalty. Cooling capacity available from the storage without concern for part load operation simplifies the overall operation of the cooling plant.

Monitoring:

Operational planing and cooling load monitoring are essential to achieve the primary objectives of using storage. With storage being an energy management system, effective control requires monitoring of the system energy status and instantaneous flows. This control is best handled by automation systems that are capable of recording and displaying data over the extended time frames of the storage cycles. Operational experience with storage systems reveals that records of historical data for seasonal operation simplify the planning operation.

Planning the operation of the system requires monitoring of the available cooling in the storage. One method is to fit the tank with a vertical arrangement of temperature sensors with spacing of 1 to 2 ft. centers, depending on the level of accuracy desired. Display of the vertical temperature profile in the tank facilitates tracking of the thermocline. A simple algorithm using operating temperatures and tank volume yields available cooling.

Operating Temperatures:

Chillers on stratified storage systems operate with discharge temperatures at or above the 39.2 density limit temperature and at or below the temperature of the bottom of the storage tank during the charging operation. Stratification requires that the water being introduced to the bottom of the tank is the same or colder than the volume in the tank. For this reason, most stratified storage systems operate with fixed leaving chiller temperature controlled by conventional chiller controls. Reducing chiller inlet temperature to the chiller at a controlled flow reduces chiller output. One method of achieving this reduction in chiller inlet temperature is the three way valve on the chiller loop in the diagram of Figure 14. Chiller leaving temperatures rise, upsetting the stratified tanks when standard chiller limit controls limit vane position at elevated inlet temperatures.

Load Prediction:

The operational plan, in most cases, is to accumulate the stored cooling during the evening, preceding the "on peak" period. When operating at or near design load conditions, this operation amounts to accumulating a full charge in the storage. When operating at part load (seasonal) conditions the ideal plan would be to accumulate only that quantity required for the next on peak operation. Accumulating a portion of the storage capacity requires a prediction of the load and provision of a safety quantity to allow for errors in predictions and avoiding the operating cost penalties of depleting the storage prior to the completion of the on peak cycle. A simplistic approach to dealing with the part load operation has been to keep the storage fully charged at all operating load conditions. Maintaining the full charge, however, incurs thermal losses representative of full load conditions. Thermal losses from chilled water storage tend to be a very small percentage of the design capacity. If only a small percentage of the design capacity is required the full charge losses can be a significant percentage of the partial day operating load.

Partial Charging:

Limited project data is available to confirm the advantage of partially charging chilled water storage systems. The results that are available indicate that the partial charging of the storage can yield energy reductions in the order of 10 to 15 % over the full charging practice.

Repeated partial charging of chilled water storage leads to eventual increased mixing in the storage due to the reduction of the density differences. There can be several thermoclines in existence in the tank at one time, giving the indication of a "smeared" thermocline. The stratification will still work with the lower density (temperature) differentials. Current indications are that the partial charging is better than the simplistic full charge practice.

Declining Tank Outlet Temperature during Charging:

During the charging process, the outlet temperature of the storage declines, similar to the rising temperature during discharge. With a fixed flow in the primary circuits through the chillers and a fixed leaving temperature, the load on the chillers reduces toward the end of each charging cycle. This drop in output moves the chillers into part load operation with a resultant increase in energy consumption. Increasing the flow through the chiller evaporators, consistent with design, reduces the energy penalty of this drop in output.

REFERENCES

1. Mackie, E. I. & Reeves G, Electric Power Research Institute EPRI-EM-4852, 1986 - Design Guide for Thermally Stratified Chilled Water Storage.

2. Gatley D.P., Riticher J.J., Successful Thermal Storage. ASHRAE Transactions 1985 Vol. 91 Part 1.

3. Wildin M.W, & Truman, C. R., -Electric Power Research Institute EPRI-EM-4352 Vols 1 & 2, 1985 - Evaluation of Stratified Chilled Water Storage.

4. Ahlgren, R.M.,December 1987, Water Treatment Technologies for Thermal Storage Systems.Electric Power Research Institute EPRI-EM-5545

5. Wildin, M. W. and Truman, C.R., "Perfomance of Stratified Vertical Cylindrical Thermal Storage Tanks: Part 1: Scale Model Tank, and Part 2: Prototype Tank", ASHRAE Transactions Vol 95,pp 1086-1105

6. Jein Yoo - An Investigation of Reynolds Number Effects in Thermally Driven Currents Applied to Stratified Thermal Storage Tanks Dessertation University of New Mexico 1986.

7a. Hudson, H.E., Uhler, R.B., Bailey, R.W., Dividing Flow Manifolds with Square Edged Laterals, Journal of the Environmental Division, EE4, Aug. 1979

7b. M[c]Nown, J.S., Discussion of Paper by Henderson et al, Journal of Environmental Engineering Division, ASCE, Vol EE4, pp 864-866, August 1980

8. Wildin, M. W., Flow Near the Inlet and Design Parameters for Stratified Chilled Water Storage ASME 91 HT 4 July 1991

9. Wildin, M. W., "Diffuser Design for Naturally Stratified Thermal Storage" - ASHRAE Transations, V96 Pt 1, 1990 pp. 1094-1110.

10. Jein Yoo, M.W. Wildin, and C.R. Truman. Initial Formation of a Thermocline in Stratified Thermal Storage Tanks. ASHRAE Transaction Paper 1986 Vol. 92 Part 2.

11. Mackie, E.I., Application of a Nozzle Matrix in Large Volume Thermal Storage, Proceedings of International Conference of Thermal Storage, Aug. 1980

12. Mackie, E. I., Thermal Storage In Robson Square ASHRAE Transactions

13. Fiorino, D. P., Thermal Energy Storage Retrofit Project at a Large Manufacturing Facility. ASHRAE Transactions 1991

14. Krieder, J.F., Field Evaluation of Chilled Water Storage ASHRAE transactions, Vol 95, Part 1

15. Andrepont, J. S. Chilled Water Storage Case Studies: The International District Heating and Cooling Association, Fifth Annual College/University Conference Proceedings, Auburn, AL, Feb. 1992

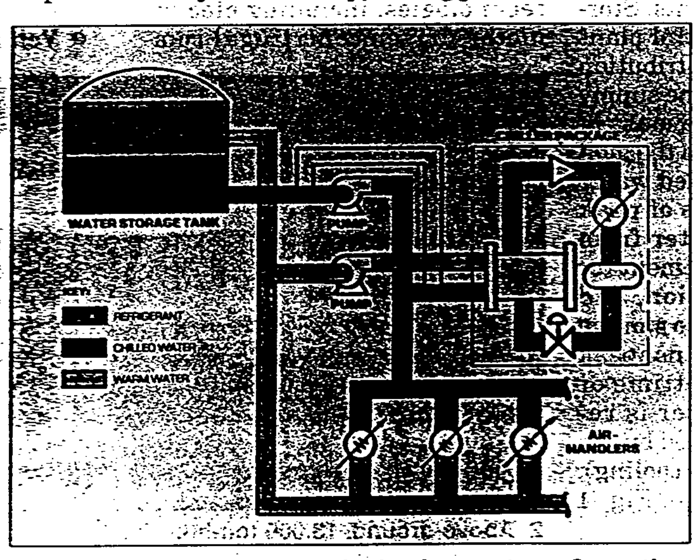
CASE STUDIES OF CHILLED WATER STORAGE

Case histories highlight central chilled water plant expansions and their relation to the CFC issue

By JOHN S. ANDREPONT,
Product Manager,
Thermal Systems,
Chicago Bridge & Iron Co.,
Oak Brook, Ill.

Centralized chilled water systems are commonly used to meet the air conditioning needs of colleges, universities, medical complexes, and other large campuses or district cooling facilities. Data from the Association of Higher Education Facilities Officers (APPA) indicate that over half its members operate central cooling plants.

Various configurations are in use, including single and multiple central chilling plants serving single distribution systems, nonconnected miniature central systems, and combinations of one central and one or more satellite plants on a single distribution loop. Central plant chillers may be electric motor-driven centrifugal compressors, gas engine-driven centrifugal compressors, steam turbine-driven centrifugal compressors, heat-driven absorption chillers, or combinations of these types. The usual refrigerants are chlorofluorocarbons (CFCs); but alternatives such as HCFCs, HFCs, ammonia (NH_3), and absorption solutions may also be employed. Free cooling via cooling towers is sometimes used, directly or indirectly, during periods of relatively low ambient air temperatures.



1 Chilled water storage peak-shaving system. Operating mode shown is real-time cooling and cooling from storage.

For the following reasons, it is often necessary to increase or upgrade a central plant's cooling capacity.

- Construction of a new facility.
- Expansion of an existing facility.
- Centralization of a distributed cooling system.
- Addition of a new building to a cooling loop.
- Increase of cooling loads at existing buildings.
- Replacement of aging chiller equipment.
- Conversion of chiller or fuel types.
- Necessary efficiency improvements.
- Phaseout or replacement of CFCs.

During any central plant capacity expansion, O&M, capital, and life cycle costs are among the major concerns, as are the increasingly critical issues of reliability, flexibility, safety, and the environment. Specifically, atmospheric ozone depletion and the CFC refrigerant issue are now impacting everyone involved in the air conditioning field. Anyone selecting or planning for new chiller capacity is faced with choosing from such options as CFCs, HCFCs, HFCs, ammonia, and absorption refrigeration. These choices have unique and serious drawbacks such as:

- CFC production is banned, effective in 2000 (possibly 1996).

This article is based on a paper presented at the 79th annual meeting of The Association of Higher Education Facilities Officers (APPA), Indianapolis, Ind., July 26-29, 1992.

- HCFC production is banned, effective in 2020 (possibly 2005).
- HFC equipment is less developed than most HCFC equipment.
- Ammonia is toxic and hazardous, which requires special precautions.
- Absorption chiller installations are generally more expensive to buy and unfamiliar to many O&M personnel.

Modifications of existing CFC equipment for HCFC or HFC use are not only costly but also projected to result in losses of capacity, typically up to 10 percent. However, an alternative approach is now experiencing increased application.

Chilled water storage option

Thermal energy storage (TES), specifically when accomplished through the use of chilled water storage, is a technology with many benefits for facilities or campuses requiring CFC phase-out or capacity expansions of their central chilled water plants. Storage is located at the central plant or remotely along the distribution loop. Connected to both the supply and return headers, the mass of water in storage provides thermal capacitance for the chilled water system. During periods of peak cooling loads, cold water from storage is used to supplement (or replace) chiller operation, and warm water is returned to storage simultaneously. During nonpeak periods (typically nighttime or weekends), warm water is removed from storage, cooled by the chiller plant (or via free cooling), and returned to storage. Fig. 1 shows a basic system.

Installations dating back to the early 1980s often configured chilled water storage in dual or multiple tanks employing the "empty tank method" to separate the supply and return water. The stored supply and return water volumes never occupied the same tank at the same time. This eliminated any chance of mixing but added volume, complexity, and cost to the systems. Other early systems employed single tanks with internal membranes or diaphragms to separate the supply and return water, which also added cost and maintenance problems.

Research and development efforts were conducted throughout the 1980s by the electric utility industry, academia, and independently by private industry. This led to a proven means for storing supply and return water volumes together in a single tank with separation being maintained via thermal stratification. Based on its superior performance and economics, thermal stratification has become the standard approach for chilled water storage.

Chilled water storage is compatible with whatever chiller technology is currently in use at central plants and, by its nature, equally compatible with whatever water chilling technology may become the choice in the 21st century. Installations already in use are being recharged by an array of technologies, including electric motor-driven centrifugal compressors, steam turbine-driven centrifugal compressors, and steam-driven absorption chillers. Although chilled water storage is not the complete answer to the CFC issue, it can often be the option of choice for central plant operators throughout the 1990s. Cooling capacity growth can usually be met via the addition of storage, thus postponing the need to buy any new chillers for 5 to 10 years or more.

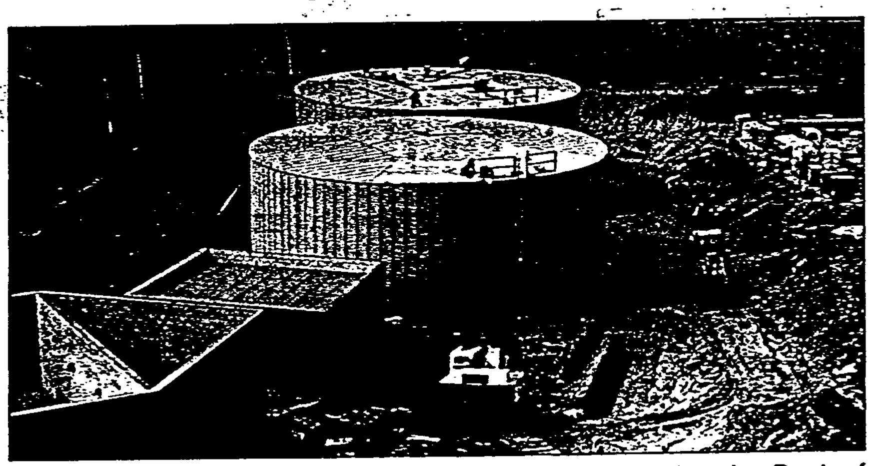
For example, recent years have seen a rapid growth in the use of chilled water storage by colleges and universities in both the public and private sectors. Installations are either operating or in the planning stages in virtually all parts of North America.

In recent years, a single storage system supplier has designed and installed chilled water storage installations representing the equivalent of over 50,000 tons of peak chiller capacity and totaling more than 500,000 ton-hr of storage capacity. (One ton-hr equals 12,000 Btuh.) Data from some of these installations will be used for illustration in the sections that follow.

Sizing criteria for storage

The required volume of storage is a function of the following variables:

- Volume is proportional to the required thermal storage capacity.
- Volume is inversely proportional to the chilled water supply-to-return temperature difference (ΔT).
- Volume is inversely proportional to the product of all volumetric and thermal efficiencies



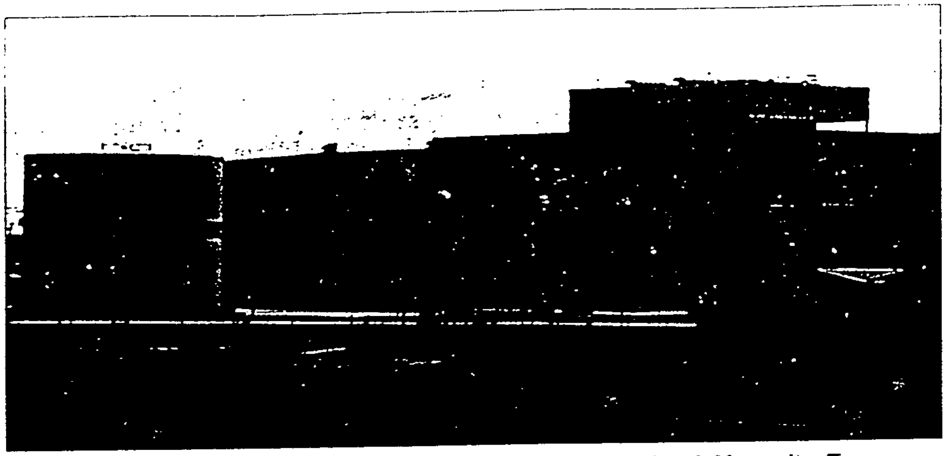
2 Above-ground, 13,000 ton-hour installation at the Los Angeles Dept. of Water and Power for its new office complex in Sun Valley, Calif.

associated with storage.

Volumetric and thermal efficiencies involve as a minimum: external heat gain; internal heat transfer; internal mass transfer (mixing); and unusable volumes due to the thermocline (temperature gradient) zone; the inlet/outlet zones; the operating water depth range; and the minimum air space (at times significant—*e.g.*, when sized for a seismic, sloshing wave). Based on allowances, an approximate rule-of-thumb for typical stratified chilled water storage installations is that the gross storage tank volume, in gallons, is equal to the capacity, in ton-hours, times 1800 divided by the temperature difference, in degrees F.

This formula is appropriate for typical tank heights (32 to 48 ft). However, many variables affect the final volume and the optimum choice of height and diameter; therefore an experienced designer or supplier should be consulted regarding the optimal size for each situation.

Similarly, care should be taken to optimize the required thermal storage capacity, which is a function of many factors, including cooling load profile, electric rate structure, electric load profile, available chiller capacity, expansion plans, and local electric utility cash incentives, if any.



3 5000 ton-hour installation at the North Mesquite High School, Mesquite, Tex.

Design and operation issues

Chilled water storage systems should be designed to accommodate various operating modes, including:

- Full storage (load shifting)—discharging storage to meet cooling loads without any concurrent chiller operation.
- Partial storage (load leveling)—discharging storage to meet cooling loads with concurrent operation of at least some chillers (in parallel with storage).
- Full recharge—recharging storage via chiller operation.
- Partial recharge—recharging storage via chiller operation while simultaneously providing cooling to the loads from the chillers.
- Standby—no circulation through storage, allowing the chillers to serve the cooling loads as they would in the absence of storage.

Where possible, the free water surface at the top of storage should be the high point of the chilled water distribution loop, which will permit the simplest system hydraulically. However, wherever this is not practical to achieve, either of the following two alternatives should be considered.

- A plate-and-frame heat exchanger can be used to segregate the system into hydraulically independent loops, a high pressure distribution loop and a low pressure storage loop. The drawbacks of this approach include the added capital cost of the heat exchanger and additional pumps and controls, and most significantly, the approach temperature at the heat exchanger, which reduces the ΔT available in storage, thus increasing the necessary storage volume. A benefit is the segregation of the stored water, allowing greater flexibility in the choice of water treatment.
- A back-pressure sustaining valve can be used to maintain the required minimum positive pressure throughout the distribution loop. Therefore, a booster pump is required for reinjection of the water from storage back into the higher pressure distribution circuit. The drawbacks of this approach include the capital cost of the control valves and pumps as well as the (usually moderate) parasitic operating cost of the booster pump. The benefit is that the ΔT and size of storage are unaffected.

It is not economically practical to design large chilled water tanks for any significant internal pressure beyond the hydrostatic pressure of the head of stored water.

Whenever possible, the chilled water system should be operated in a manner that maximizes the supply-to-return temperature difference (ΔT). This can most easily be accomplished through the use of variable flow chilled water pumping and two-way, rather than three-way, control valves at the cooling loads. Maximizing the ΔT will minimize storage volume and capital cost. The ΔT for typical storage installations ranges from below 10 F to over 20 F, but higher is better.

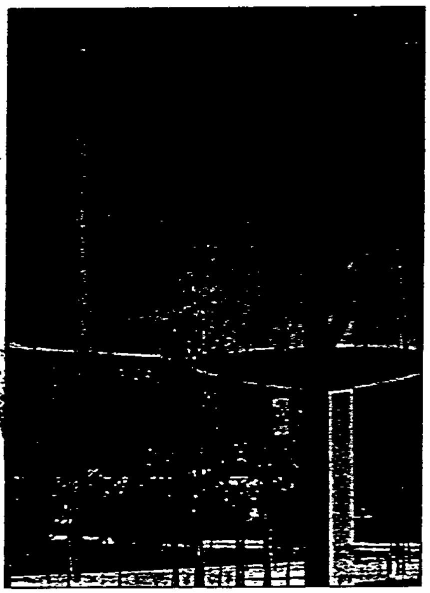
Maintenance issues

Maintenance for a stratified chilled water storage system should always be less than for equivalent conventional chiller plant capacity. Although early methods of chilled water storage did involve maintenance-intensive components (*e.g.*, the large membranes or diaphragms of membrane-separated storage or the large switching valves of

"empty tank method" storage), stratified storage requires no moving parts.

Maintenance of the storage element is largely limited to periodic (long-term) cycles of repainting and reinsulating and to water treatment. Properly installed systems can be expected to experience approximately 10 to 15 years between repainting and 15 to 25 years or more before reinsulating.

Water treatment requirements vary with each installation based on unusual combinations of water chemistry and materials of construction within the distribution



4 Carillon (bell tower) tank on the campus of the State University of New York, Albany, N.Y.

system. Water treatment is not required to protect most storage tanks as the tanks themselves are lined with a paint system approved by the American Water Works Association (AWWA), which is identical to one used for municipal potable water storage tanks. Typical installations do involve an initial treatment of the storage volume for purposes of protecting the balance of the piping system from corrosion, biological growth, etc. Initial costs are usually in the range of one to several cents per gallon treated. On-going treatment costs for the chilled water system are generally unchanged by the addition of storage.

A program of regular monitoring, inspection, and remedial action (as necessary) is recommended to ensure long life. In any case, maintenance should be less than for the chiller and cooling tower capacity avoided by the use of storage.

Above- vs. below-ground

Consideration is sometimes given to locating storage partially or fully below grade. This may be for esthetic reasons or to allow the on-going utilization of the location for other purposes, such as parking, an athletic field, or a green space. Placing storage below grade should be done only after considering the following various factors.

- System hydraulics are often complicated by a below-ground tank.
- The tank should be designed for external pressure for instances when the tank is empty.
- Soil and groundwater conditions can impact design and cost.
- Regulations regarding buried tanks are increasingly restrictive.
- Choice of water treatment may be limited if the tank is buried.
- Total capital cost is often double that of an above-ground tank.

For example, a 54,000 ton-hour, 5.5 million gal chilled water storage system was recently installed at Arizona State University in Tempe. This direct-buried storage facility, which was located beneath an athletic field out of necessity, incurred an installed cost of $5.1 million. At about the same time, a 68,000 ton-hour, 6.1 million gal above-ground installation for Chrysler's new R&D campus was completed outside Detroit, Mich. The above-ground storage installation was completed for only $2.6 million.

If the top of storage must be kept low, a technically and economically viable alternative may be to build an above-ground tank within an excavated depression. This was done for the 13,000 ton-hour installation for the Los Angeles Dept. of Water and Power at its new office complex in Sun Valley, Calif. (Fig. 2).

Steel vs. concrete

Neither concrete nor steel tanks are maintenance free. However, lower initial costs and lower life cycle costs for steel construction have led to the dominance of steel tanks throughout the range of water storage applications, whether for municipal, fire protection, or chilled water storage. Some steel water storage tanks have been documented to achieve more than 100 years of continuous service.

Concrete water storage tanks are typically specified, designed, and constructed in accordance with AWWA Standard D-110. However, even this standard permits leakage rates of up to one tenth of one percent of the tank capacity per day. For a 3 million gal tank, this equates to over 1 million gal of leakage per year! Welded-steel tanks by contrast can be selected, installed, and tested in accordance with AWWA Standard D-100, which does not permit any leakage.

Thin-walled steel tanks also offer a performance advantage over thick-walled concrete tanks. The thermal capacitance of the tank wall must be alternately cooled and reheated, across the operating ΔT, during each cycle of the chilled water storage system. This represents an inherent storage inefficiency that is roughly an order of magnitude larger for the more massive concrete tanks.

Esthetic considerations

Esthetics is often an issue for chilled water storage, particularly for college and university campuses and for sensitive private industry sites.

In some cases, even large multimillion gallon storage tanks can be effectively hidden from public

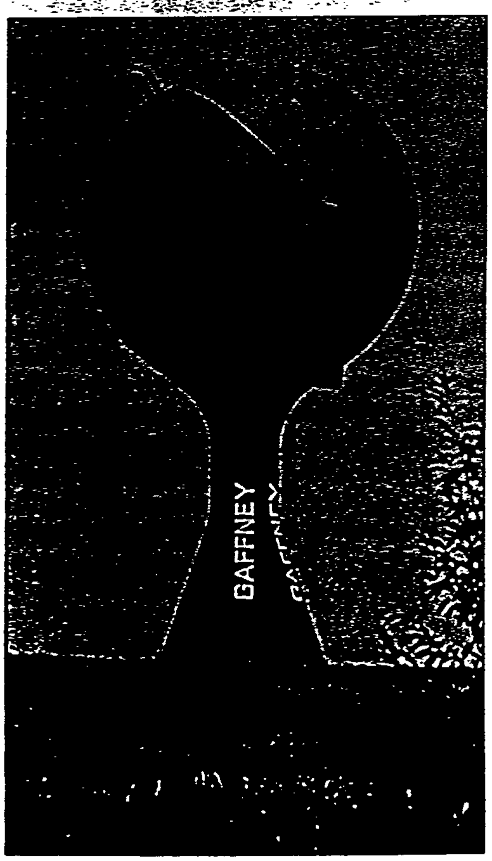
continued on page 111

continued from page 108

view through careful placement behind central plant buildings or trees. Where tanks cannot be hidden from view, it is possible to choose a tank shape and an insulation finish either to blend with or complement the surrounding architecture or to make their own visual statements.

Conventional choices include various roof styles (cone, dome, ellipsoidal, etc.) and insulation types (urethane foam without a rigid jacket, foam panels with horizontally strapped aluminum jacketing, or foam panels with vertically ribbed aluminum jacketing). Various paint colors are available, as are custom paint schemes, which the North Mesquite High School "Stallions" in Mesquite, Tex. used on its 5000 ton-hour installation (Fig. 3).

Chilled water storage tanks are also available with a synthetic stucco insulation system that permits custom combinations for color, texture, and three-dimensional relief to achieve virtually any desired architectural style. Storage tank suppliers have also built many one-of-a-kind tanks such as the carillon (bell tower) tank on the campus of the State University of New York at Albany (Fig. 4) and the 1 million gal "Peachoid" in Gaffney, S.C. (Fig. 5).



5 One million gallon "Peachoid," Gaffney, S.C.

Dual-service applications

Approximately 30 percent of a leading supplier's chilled water storage installations are designed for dual-service applications where, in addition to thermal storage, they provide fire protection water storage. This is possible because of two characteristics:

- Thermally stratified chilled water storage tanks operate full at times, with all the water available for fire protection if needed.
- When used for fire protection, tanks must be designed, constructed, and tested in accordance with the National Fire Protection Association's Standard NFPA 22—*Water Tanks for Private Fire Protection.*

In addition, chilled water storage for dual-service thermal/fire protection applications can be provided with Factory Mutual approval, as was obtained for the 8500 ton-hour installation at the Phoenix Newspaper's new printing facility in Phoenix, Ariz.

O&M cost

The use of chilled water storage as thermal capacitance within a central chilled water distribution system provides various operating and maintenance benefits. Decoupling the chillers from the time-varied cooling load profile allows them to be operated at full or optimum capacity levels, avoiding inefficient, severe part-load conditions. Increased nighttime use of chillers also results in efficiency improvements due to the lower condensing temperatures. On the maintenance side, less total chiller capacity is required, thus reducing the size or quantity of installed chillers, cooling towers, condenser pumps, and fans and yielding a reduction in equipment maintenance costs.

However, the greatest importance for O&M costs is, in the case of electric motor-driven chillers, the significant reduction in facility peak electric demand charges and the shifting of electrical energy consumption from high-cost on-peak periods to low cost off-peak periods at night. It is common to achieve simple paybacks on investment of 1 to 2 years or better.

The Austin (Texas) Independent School District is now in its fourth year of operation of the 2600 ton-hour storage system at the 2000 to 3000 student James Bowie High School. After earning a $95,450 cash incentive from the City of Austin Electric Dept., the school district achieved a simple payback of only 10 months based on a combination of operating and maintenance savings of over $25,000 per year.

In 1991, the Brazosport Community College in Lake Jackson, Tex., (a campus of 3000 to 4000 students) brought its 4000 ton-hour storage tank on-line. The system eliminated the need for 600 tons of new chiller capacity, earning a cash incentive of $152,200 from its electric utility, Houston Lighting & Power. Annual electric energy savings for the college were independently estimated to be $62,500 at current electric rates with more in the future.

Recent chilled water storage installations at the Sacramento campus of California State University and at the Hershey Medical Center at Pennsylvania State University provide 12,300 and 12,500 ton-hours of storage, respectively. The CSU-Sacramento

system avoided the need for 2500 tons of chillers and cooling towers, achieving a peak electric demand saving of 2000 KW and earning approximately $400,000 of cash incentive from Pacific Gas & Electric (Fig. 6). The medical center avoided 1500 tons of chillers and cooling towers for a demand reduction of about 1200 KW and a cash incentive of $100,000 from Pennsylvania Power & Light.

The 68,000 ton-hour system at Chrysler Motors Corp.'s new Technology Development Center campus in Auburn Hills, Mich., represents a peak electric demand reduction of 5.3 megawatts. At current Detroit Edison electric rates, this equates to a demand saving of $74,000 per month or nearly $1 million annually.

Capital cost savings

In the case of large chilled water storage installations, it is common to achieve not merely rapid paybacks but immediate capital cost savings, even without utility cash incentives. This is achieved (either for new construction or for retrofit capacity expansions or replacements) through the use of central chiller plants sized not for the peak load (plus spare capacity) but for the average load over a 24 hr peak design-day, plus spare capacity). The dramatic economy of scale inherent to large tank construction results in installed tank costs that are less than the avoided cost of installed conventional chiller plant capacity.

In the mid-1980s, General Motors Corp. planned an expansion of its GMC Truck and Bus plant in Pontiac, Mich., requiring an increase in the peak chiller plant capacity from 5000 to 7000 tons. GM chose to install a 17,000 ton-hour chilled water system (2000 tons times 8.5 hr) rather than a conventional 2000-ton electric chiller addition or a 2000-ton absorption chiller addition. The chilled water storage system is recharged without the need for any new chillers, simply using the otherwise unused nighttime capacity of the original 5000-ton central plant. GM realized an immediate capital cost saving (versus the cost of an electric chiller capacity addition) of $196,000 or essentially $100 per ton installed without any utility cash incentive.

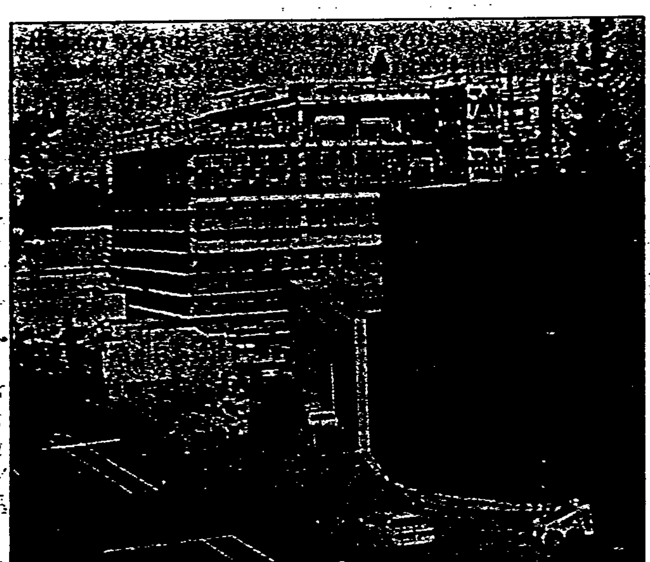
Chrysler's 68,000 ton-hour system provided even greater savings. Through the addition of storage, its requirement for new central plant capacity was reduced from 17,700 tons to 11,400 tons. Chrysler realized an immediate capital cost saving of $3.6 million, again without any utility cash incentives.

Capital savings need not stop at the central plant. Storage can sometimes be advantageously located (as one might do with a satellite chiller plant) somewhere along the distribution loop remote from the central plant. In this manner, the chilled water pumping and pipeline capacity can be peak-shaved as well. Smaller pumps and piping can be installed initially, or for cases of retrofit growth of a distribution loop, the need to increase the diameter of existing piping can be avoided. And unlike a satellite chiller plant, a remote storage tank does not require additional O&M personnel.

Contracting for performance

The chilled water storage tank is a critical performance element of any air conditioning system of which it is a part. Not only is the thermal storage capacity critical, so too are the rates at which storage can be charged and discharged, the ambient heat gain, the discharge temperatures, and the pressure drop.

It is common, and recommended, to procure storage through the use of a performance type specification in the same manner commonly employed to procure a chiller, a cooling tower, or any other major mechanical equipment element of a central plant. Chilled water storage installations should be provided to meet such requirements, including a guarantee of both leak tightness and thermal performance.



6 12,300 ton-hour installation at the Sacramento campus of California State University.

Increasingly, it is also possible to contract with third parties who design, finance, install, and operate systems. Various possible arrangements include shared savings, guaranteed savings, and lease/purchase contracts.

Summary and conclusions

Chilled water storage is experiencing rapid growth in applications for large central chilled water systems. With or without utility cash incentives, storage can provide not only significant O&M savings but a low capital cost option versus conventional central plant capacity additions.

Chilled water storage offers an option for capacity additions without adding CFCs. It will allow many facilities to meet their immediate growth needs while postponing new chiller acquisitions for 5 to 10 years, at which time new refrigerant and new equipment choices should be much clearer than at present. Storage will, by its nature, be compatible with whatever water chilling technology is chosen in the future.

The technology evolved through the 1980s to the point where chilled water storage is now available with various esthetic options and guarantees of leak tightness and thermal performance. The dozens of installations currently in operation are likely to be the predecessors of many, many more in the years to come. Ω

Bibliography

1) "Summary of Central Cooling/Heating Plant Data," from *Survey of Colleges and Universities*, 1986.

2) APPA, *Survey of Thermal Energy Storage Installations in the U.S. and Canada*, ASHRAE, ISBN 0-910110-37-9, 1984.

3) *Thermal Energy Storage System Incentive Program Submittal at Bowie High School*, BLGY, Inc., Austin, Tex., May 1989.

4) Carver, G. L., *Thermal Energy Storage for the Large and Small Campus*, Proceedings of the 77th Annual Meeting of APPA, Ottawa, Ontario, July 1-4, 1990.

5) Dahir, M. S., "Tangled Refrigerant Issues Leave Users, Vendors Perplexed," *Energy User News*, January 1992.

6) Holness, G. V. R., "Thermal Storage Retrofit Restores Dual Temperature System," *ASHRAE Transactions*, Paper No. DA-88-25-2, Dallas, Tex., February 1988.

7) *Steel Tanks*, Steel Plate Fabricators Association, Inc., Westchester, Ill., undated.

8) Warren, M., *Thermal Energy Storage System for Brazosport College*, ACR Engineering, Inc., Austin, Tex., June 26, 1990.

IN-91-20-2

CASE STUDY OF A LARGE, NATURALLY STRATIFIED, CHILLED-WATER THERMAL ENERGY STORAGE SYSTEM

D.P. Fiorino, P.E.
Member ASHRAE

ABSTRACT

This case study describes a 24,500 ton-hour (310,199 MJ) thermal energy storage system with a 2.681 million gallon (10,161 m³) naturally stratified, cylindrical, chilled-water storage reservoir serving a 1.142 million ft² (106,092 m²) electronics manufacturing facility in Dallas, TX. This retrofit project was completed in 10½ months at a total cost of less than $70.00 per ton-hour ($5.53 per MJ) and has performed well since start-up in August 1990, enabling the facility to reduce its peak electrical demand by 2.9 MW (e). Several of its design features and operating methods are discussed in detail for the benefit of engineers interested in chilled-water thermal energy storage.

INTRODUCTION

The purpose of the thermal energy storage system was to shift 2.9 MW (e) of electrical demand related to operation of the facility's existing 4,200-ton (14,771-kJ/s) central chiller plant from on-peak to off-peak in order to reduce annual electricity costs and offset anticipated electric rate increases.[1] Given a major cash incentive from the local electric utility and a favorable time-of-day rate option, a thermal energy storage retrofit project involving the installation of a naturally stratified chilled-water storage reservoir interconnected with the facility's central chiller plant was determined to be feasible and cost-effective (Table 1). Following project review and approval, construction was completed between September 30, 1989, and August 13, 1990.

A 2.681 million gallon (10,161 m³) ANSI/AWWA Standard D110-86 (Type III) precast, prestressed, cylindrical concrete water tank with an enclaved steel diaphragm and a clear-span spherical dome roof was installed as the cold storage reservoir. Thousands of tanks of this design have been used for water storage and waste water process applications in hundreds of communities throughout the United States for many years with an excellent record of reliability, low maintenance, and environmental adaptability. The use of a continuous, mechanically bonded, embedded steel diaphragm in the tank's circular wall ensures watertightness. Tension cracks are eliminated by wrapping the entire tank from top to bottom in multiple layers of high-strength steel wire stressed to 140,000 psi (964,600 kpa). In the application under study, the cold storage reservoir was buried to the top of its circular wall, and its spherical dome roof was insulated with 2 in. (51 mm) thick spray-on polyurethane foam, a butyl vapor barrier, and a highly reflective white urethane top coat (Figure 1).

An integral primary/secondary "bridge" was installed as the interface between the cold storage reservoir's 16 in. (406 mm) diameter transfer piping system, i.e., the primary circuit, and the facility's existing multi-zone distribution piping system, i.e., the secondary circuit. It physically and hydraulically connects the primary and secondary circuits, placing the variable-speed distribution pumps in the supply of each of the facility's two secondary subcircuits in series with the constant-speed transfer pumps in the primary circuit. It also ensures the highest possible primary temperature differential at the lowest possible primary flow rate by recirculating warm water from the common secondary return line into the common secondary supply line via a one-way crossover line.

A distributed, direct digital control (DDC) system synchronizes primary/secondary flow rates and provides sustaining pressure-modulated control of secondary return water temperature throughout the entire cycle of operation. During the charge cycle, it operates the centrifugal chillers at 100% of capacity and provides flow-modulated control of evaporator leaving water temperature. At cycle switch-over, it reverses flow direction in the lines transferring warm and cold water to and from the cold storage reservoir without shutting off the transfer pumps. It also has a PC-based graphical interface that enables the operator to continuously monitor the system's performance, including the tempera-

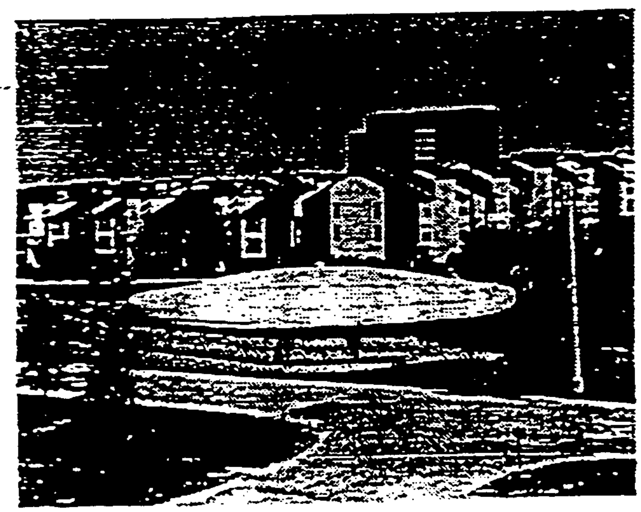


Figure 1 Cylindrical reservoir

[1]The anticipated electric rate increases were related to a 2,300 MW (e) nuclear generating station costing $10 billion. Start-up of its first 1,150 MW (e) generating unit in mid-1990 resulted in a 54% increase in the demand charge paid by the facility.

Donald P. Fiorino is a Facility Engineer and a Member of the Group Technical Staff at Texas Instruments, Inc., Dallas, TX.

Chilled water storage offers an option for capacity additions without adding CFCs. It will allow many facilities to meet their immediate growth needs while postponing new chiller acquisitions for 5 to 10 years, at which time new refrigerant and new equipment choices should be much clearer than at present. Storage will, by its nature, be compatible with whatever water chilling technology is chosen in the future.

The technology evolved through the 1980s to the point where chilled water storage is now available with various esthetic options and guarantees of leak tightness and thermal performance. The dozens of installations currently in operation are likely to be the predecessors of many, many more in the years to come. Ω

Bibliography

1) "Summary of Central Cooling/Heating Plant Data," from *Survey of Colleges and Universities,* 1986.

2) APPA, *Survey of Thermal Energy Storage Installations in the U.S. and Canada,* ASHRAE, ISBN 0-910110-37-9, 1984.

3) *Thermal Energy Storage System Incentive Program Submittal at Bowie High School,* BLGY, Inc., Austin, Tex., May 1989.

4) Carver, G. L., *Thermal Energy Storage for the Large and Small Campus,* Proceedings of the 77th Annual Meeting of APPA, Ottawa, Ontario, July 1-4, 1990.

5) Dahir, M. S., "Tangled Refrigerant Issues Leave Users, Vendors Perplexed," *Energy User News,* January 1992.

6) Holness, G. V. R., "Thermal Storage Retrofit Restores Dual Temperature System," *ASHRAE Transactions,* Paper No. DA-88-25-2, Dallas, Tex., February 1988.

7) *Steel Tanks,* Steel Plate Fabricators Association, Inc., Westchester, Ill., undated.

8) Warren, M., *Thermal Energy Storage System for Brazosport College,* ACR Engineering, Inc., Austin, Tex., June 26, 1990.

IN-91-20-2

CASE STUDY OF A LARGE, NATURALLY STRATIFIED, CHILLED-WATER THERMAL ENERGY STORAGE SYSTEM

D.P. Fiorino, P.E.
Member ASHRAE

ABSTRACT

This case study describes a 24,500 ton-hour (310,199 MJ) thermal energy storage system with a 2.681 million gallon (10,161 m³) naturally stratified, cylindrical, chilled-water storage reservoir serving a 1.142 million ft² (106,092 m²) electronics manufacturing facility in Dallas, TX. This retrofit project was completed in 10½ months at a total cost of less than $70.00 per ton-hour ($5.53 per MJ) and has performed well since start-up in August 1990, enabling the facility to reduce its peak electrical demand by 2.9 MW (e). Several of its design features and operating methods are discussed in detail for the benefit of engineers interested in chilled-water thermal energy storage.

INTRODUCTION

The purpose of the thermal energy storage system was to shift 2.9 MW (e) of electrical demand related to operation of the facility's existing 4,200-ton (14,771-kJ/s) central chiller plant from on-peak to off-peak in order to reduce annual electricity costs and offset anticipated electric rate increases.[1] Given a major cash incentive from the local electric utility and a favorable time-of-day rate option, a thermal energy storage retrofit project involving the installation of a naturally stratified chilled-water storage reservoir interconnected with the facility's central chiller plant was determined to be feasible and cost-effective (Table 1). Following project review and approval, construction was completed between September 30, 1989, and August 13, 1990.

A 2.681 million gallon (10,161 m³) ANSI/AWWA Standard D110-86 (Type III) precast, prestressed, cylindrical concrete water tank with an enclaved steel diaphragm and a clear-span spherical dome roof was installed as the cold storage reservoir. Thousands of tanks of this design have been used for water storage and waste water process applications in hundreds of communities throughout the United States for many years with an excellent record of reliability, low maintenance, and environmental adaptability. The use of a continuous, mechanically bonded, embedded steel diaphragm in the tank's circular wall ensures watertightness. Tension cracks are eliminated by wrapping the entire tank from top to bottom in multiple layers of high-strength steel wire stressed to 140,000 psi (964,600 kpa). In the application under study, the cold storage reservoir was buried to the top of its circular wall, and its spherical dome roof was insulated with 2 in. (51 mm) thick spray-on polyurethane foam, a butyl vapor barrier, and a highly reflective white urethane top coat (Figure 1).

An integral primary/secondary "bridge" was installed as the interface between the cold storage reservoir's 16 in. (406 mm) diameter transfer piping system, i.e., the primary circuit, and the facility's existing multi-zone distribution piping system, i.e., the secondary circuit. It physically and hydraulically connects the primary and secondary circuits, placing the variable-speed distribution pumps in the supply of each of the facility's two secondary subcircuits in series with the constant-speed transfer pumps in the primary circuit. It also ensures the highest possible primary temperature differential at the lowest possible primary flow rate by recirculating warm water from the common secondary return line into the common secondary supply line via a one-way crossover line.

A distributed, direct digital control (DDC) system synchronizes primary/secondary flow rates and provides sustaining pressure-modulated control of secondary return water temperature throughout the entire cycle of operation. During the charge cycle, it operates the centrifugal chillers at 100% of capacity and provides flow-modulated control of evaporator leaving water temperature. At cycle switch-over, it reverses flow direction in the lines transferring warm and cold water to and from the cold storage reservoir without shutting off the transfer pumps. It also has a PC-based graphical interface that enables the operator to continuously monitor the system's performance, including the tempera-

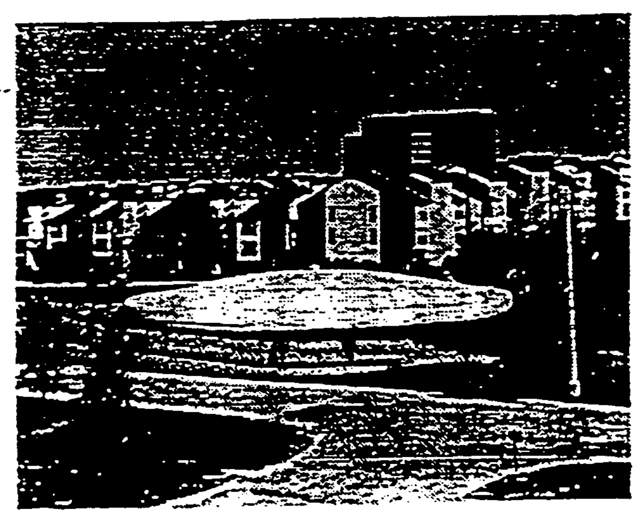


Figure 1 Cylindrical reservoir

[1] The anticipated electric rate increases were related to a 2,300 MW (e) nuclear generating station costing $10 billion. Start-up of its first 1,150 MW (e) generating unit in mid-1990 resulted in a 54% increase in the demand charge paid by the facility.

Donald P. Fiorino is a Facility Engineer and a Member of the Group Technical Staff at Texas Instruments, Inc., Dallas, TX.

TABLE 1
System Design Parameters

Parameter	Value
Integrated Cooling Load	24,500 ton-hours (310,199 MJ)[1]
Instantaneous Cooling Load	3,200 tons (11,254 kJ/s)[2]
Charge Cycle Duration	16 hours[3]
Charge Inlet Temperature	40°F (4.4°C)[4]
Discharge Cycle Duration	8 hours[5]
Limiting Discharge Cycle Outlet Temperature	42°F (5.6°C)[6]
Discharge Inlet Temperature	56°F (13.3°C)[7]
Reservoir Diameter	105.5 ft (32.16 m)[8]
Reservoir Depth	41 ft (12.50 m)
Reservoir Volume	2,680,904 gal (10,161 m³)
Usable Reservoir Volume	90%[9]

[1]Includes a 15% allowance for storage heat gain, transfer pump heat gain, and future integrated cooling load growth.
[2]Includes a 14% allowance for future instantaneous cooling load growth.
[3]Extends from 8:00 p.m. to 12:00 noon.
[4]Limited by the density inversion of water at 39.2°F (4.0°C).
[5]Extends from 12:00 noon to 8:00 p.m.
[6]Limited by economic sizing of the transfer pumps and piping.
[7]Limited by the 58.3°F (14.6°C) average design leaving water temperature of the facility's existing chilled-water cooling coils—less a 2.3°F (1.3°C) allowance for bypass, laminar flow, etc.
[8]Limited by the space available as well as a zoning requirement to take a 10 ft (3.05 m) minimum property line setback.
[9]Recommended in the *EPRI Stratified Chilled Water Storage Design Guide*.

ture profile inside the cold storage reservoir and electric demand at the facility's power meter.

DIFFUSER DESIGN CRITERIA

In order to realize maximum integrated cooling capacity, the diffuser system must simultaneously introduce and withdraw flow from the cold storage reservoir with minimum mechanical disturbances, i.e., mixing, during the entire cycle of operation. This allows a thermocline zone to form and maintain separation of the lighter warm water, stored above, from the heavier cold water, stored below, without a physical barrier (Figure 2).[1] Diffuser design criteria developed as the result of performance testing of various designs of diffuser systems in both scale-model and prototypical naturally stratified, cylindrical, chilled-water storage tanks (Wildin and Truman 1989) were adopted for use in the application under study:

1. Inlet Reynolds number (Re_i) of 850 or less.[2]

$$Re_i = q/v \tag{1}$$

where

q = volume flow rate per unit diffuser length
v = kinematic viscosity of the inlet water.

2. Inlet Froude number (Fr_i) of 2.0 or less.[3]

[1]A thermocline zone is a thin, horizontal layer of water with a steep vertical temperature gradient.
[2]The inlet Reynolds number is the dimensionless ratio of inertial and viscous forces.
[3]The inlet Froude number is the dimensionless ratio of inertial and buoyancy forces.

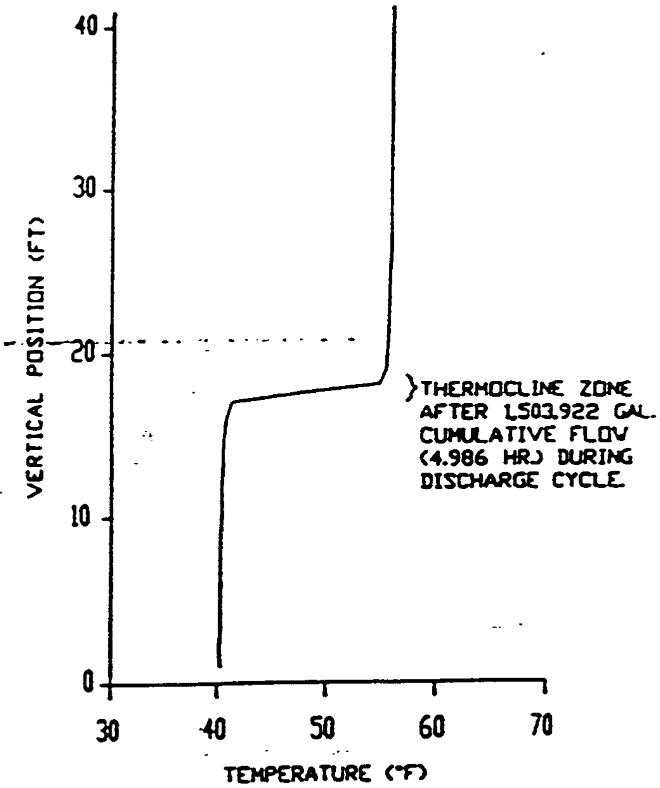


Figure 2 Prediction of thermal performance

$$Fr_i = q/(g \times h_i^3 \times (P_i - P_a)/P_a)^{1/2} \tag{2}$$

where

g = acceleration of gravity
h_i = minimum inlet opening height
P_i = density of the inlet water
P_a = density of the ambient water.

3. Uniform flow velocity at all diffuser openings.
4. Self-balancing at all flow conditions.

SINGLE-OCTAGON DIFFUSER

Recent research on diffuser performance disclosed that a single-octagon diffuser system (Figure 3) with an inlet

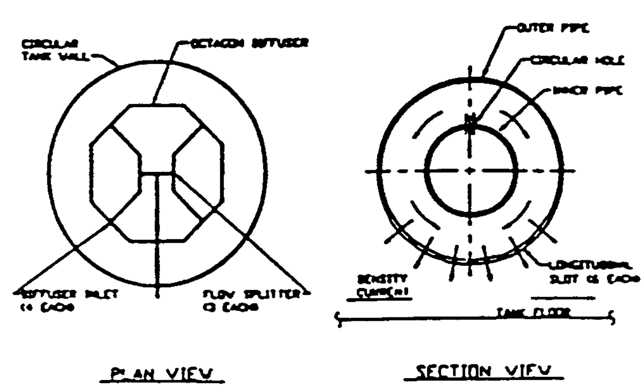


Figure 3 Single-octagon diffuser

Reynolds number (Re_i) of 240 had produced little mixing and stratified well in a 35,300 gal (134 m^3), partially insulated, cylindrical, post-tensioned concrete chilled-water storage reservoir (Wildin and Truman 1989). In repeated tests, the single-octagon diffuser system performed well, demonstrating single-cycle figures of merit as high as 88.5% under optimal operating conditions.[5] Based on these results, the single-octagon diffuser system was selected for the application under study and an initial design was attempted. Because the resultant inlet Reynolds number (Re_i) of 1,508 was greater than permitted by the first diffuser design criterion, an analysis was made to determine how it might be reduced.

One factor impacting the result was the system's relatively low discharge temperature differential of 15.0°F (8.3°C), which caused its maximum volume flow rate (Q) of 5,120 gpm (323 L/s) to be relatively high.[6] Another factor impacting the result was the cold storage reservoir's relatively high height-to-diameter ratio of 0.39, which caused its diameter to be relatively low and limited the effective length (L) of the single-octagon diffuser system.[7] Because the volume flow rate per unit diffuser length (q), which appears in the numerators of Equations 1 and 2, is related to the maximum volume flow rate (Q) and the effective diffuser length (L), as shown in Equation 3 below, it became clear that both of these factors contributed to increasing the inertia of the water being introduced into the cold storage reservoir.

$$q = Q/L. \tag{3}$$

The maximum volume flow rate (Q) is a function of system design and cannot be changed by diffuser design practices. However, the effective diffuser length (L) is, by definition, a function of diffuser design. Therefore, the approach adopted to reduce the volume flow rate per unit diffuser length (q) and, in turn, reduce the inlet Reynolds and Froude numbers (Re_i, Fr_i) was to increase the effective diffuser length (L) of the octagonal diffuser system.

DOUBLE-OCTAGON DIFFUSER

Increasing the effective length (L) of the octagonal diffuser system was accomplished by employing two octagons, arranged concentrically, with both octagons centered on the cold storage reservoir's vertical axis (Figures 4 through 6). In order to promote formation of a uniform and continuous density current across the cold storage reservoir's entire plan area, each octagon introduces 50% of the maximum volume flow rate (Q). Also, the areas inside the inner octagon and between the outer octagon and the cold storage reservoir's circular wall are each equal to 25% of the cold storage reservoir's total plan area. Furthermore, the area between the inner and outer octagons is equal to 50% of the cold storage reservoir's total plan area.

Based on the above, design of a double-octagon diffuser system was attempted (Appendix A), revealing that the double-octagon diffuser system had approximately twice the effective length (L) of the single-octagon diffuser system. The inlet Reynolds numbers (Re_i) of 1,068 and 615 for the inner and outer octagons, respectively, of the double-octagon diffuser system were significantly lower than the inlet Reynolds number (Re_i) of 1,508 for the single-octagon diffuser system and were reasonably close to the value of 850 given in the first diffuser design criterion. Also, given a common inlet opening height (h) of 5.64 in. (143 mm), inlet Froude numbers (Fr_i) of [illegible] and [illegible] were realized for the inner and outer octagons, respectively.

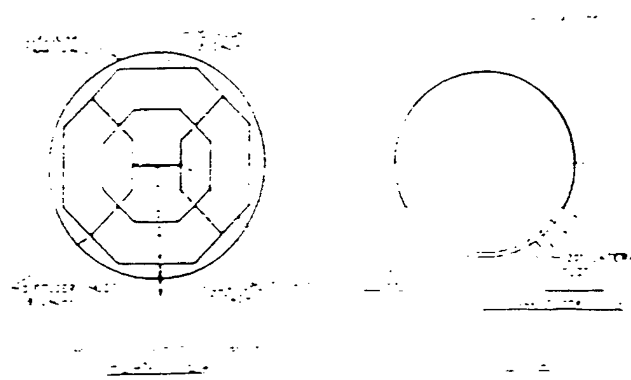


Figure 4 Double-octagon diffuser

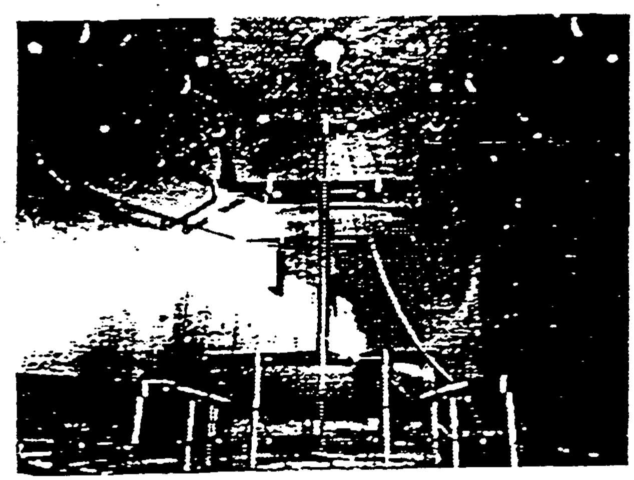


Figure 5 Double-octagon diffuser

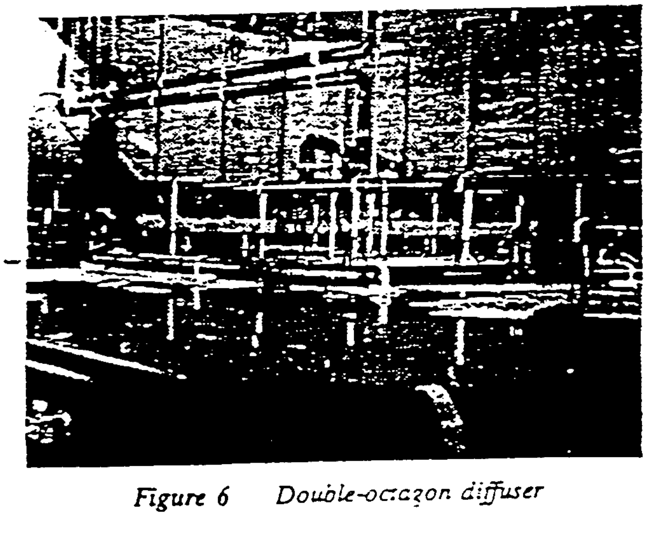


Figure 6 Double-octagon diffuser

[5] The figure of merit is a dimensionless index that accounts for losses in thermal energy storage capacity due to mixing and heat transfer through the thermocline zone, heat transfer between the ambient water and the reservoir's floor and wall, and heat transfer between the reservoir and its surroundings.

[6] Discharge temperature differentials of 10.0° to 25.0°F (5.6° to 13.9°C) are common in chilled-water thermal energy storage applications, with retrofit projects most often being toward the low end of the range.

[7] A height-to-diameter ratio of 0.25 and 0.33 is considered optimal for a naturally stratified chilled-water thermal energy storage reservoir.

UNIFORM FLOW VELOCITY

Having satisfied the first and second diffuser design criteria pertaining to acceptable values for the inlet Reynolds number (Re_i) and inlet Froude number (Fr_i), respectively, it was next necessary to satisfy the third diffuser design criterion pertaining to uniform flow velocity at all diffuser openings. Regarding this, the single-octagon diffuser system had employed an inner pipe drilled with equally sized and spaced holes to promote uniform flow velocity along its entire perimeter length (Wildin and Truman 1988; Figure 3). The outer pipe had a pattern of three longitudinal slot-shaped openings on either side of its vertical centerplane that introduced flow into the cold storage reservoir in individual flow streams, which then merged to form a continuous horizontal density current propagating equally in both the inward and outward radial directions.[8]

In the application under study, these two functions were more cost-effectively accomplished by using equally spaced lateral slot-shaped openings along the perimeter lengths of the inner and outer octagons (Appendix B and Figure 4). By spacing 0.25 in. (6.4 mm) wide lateral slot-shaped openings at 6 in. (162 mm) and 10.5 in. (267 mm) intervals along the perimeter of the inner and outer octagons, respectively, the total area of the slot-shaped openings in each of the 12 in. (305 mm) diameter linear diffuser pipes was maintained equal to the linear diffuser pipes' common cross-sectional area, i.e., 0.78 ft^2 (0.07 m^2), ensuring uniform flow velocity at all diffuser openings without using an inner pipe drilled with equally sized and spaced holes.

Also, by centering the 120° (2.09 rad) lateral slot-shaped openings on the vertical centerplanes of the linear diffuser pipes, flow was introduced into the cold storage reservoir in individual fan-shaped flow streams, which then merged to form a continuous horizontal density current propagating equally in both the inward and outward radial directions in much the same manner as the single-octagon diffuser system. Furthermore, the low inlet velocity of 0.9 ft/s (0.274 m/s) precluded turbulent, jet-like flow near the diffuser openings.

SELF-BALANCING

The last diffuser design criterion remaining to be satisfied pertained to self-balancing under all flow conditions. The single-octagon diffuser system had employed a distribution system involving three flow-splitters that distributed equally subdivided flow from a single incoming pipe at the cold storage reservoir's vertical axis into four horizontal branch pipes extending radially outward (Wildin and Truman 1988; Figure 3).[9] In turn, the four horizontal branch pipes introduced the flow into four reduced-diameter inlets spaced equally along the octagon's perimeter length. This distribution system was adopted for the double-octagon diffuser system with two modifications (Figure 4):

1. Flow-splitters were added in the horizontal branch pipes at the mid-point between the inner and outer octagons.
2. Pipe diameter reductions were taken at each flow-splitter rather than at the inlets to the inner and outer octagons.

In this manner, the distribution system for the double-octagon diffuser system maintains the symmetry and equal pressure drop characteristics of the single-octagon diffuser system, ensuring equal subdivision of flow. In addition, the distribution system for the double-octagon diffuser system reduces flow velocity and momentum by nearly 75% before it reaches the inlets to the inner and outer octagons. This reduces dynamic pressure at the inlets to the inner and outer octagons and, in turn, reduces viscous pressure drops and static pressure gains inside the 12 in. (305 mm) diameter linear diffuser pipes, ensuring uniform internal static pressure throughout the inner and outer octagons and promoting uniform flow velocity at all diffuser openings.[10]

In the application under study, the maximum flow velocity at the inlets to the inner and outer octagons is 1.84 ft/s (0.561 m/s). Because the flow splits equally into two directions as it enters the inner and outer octagons, its maximum velocity inside the linear diffuser pipes is reduced to 0.92 ft/s (0.280 m/s)—approximately equal to the desired maximum outlet velocity of 0.9 ft/s (0.274 m/s).

COMMISSIONING

Following completion of the construction phase, the chilled-water thermal energy storage system was started up on August 13, 1990, according to systematic, documented start-up procedures (Utesch 1990). During a commissioning phase extending from August 13 to August 31, 1990, the system was operated continuously at full-load cooling conditions; the operators were closely supervised in the operation of the system; the system was tested, adjusted, and balanced; and operational problems were identified and corrected.[11]

The system performed as intended, allowing the facility's central chiller plant to be entirely shut off from 12:00 noon to 8:00 p.m. daily during full-load cooling conditions and fulfilling its objective of shifting 2.9 MW (e) of electrical demand from on-peak to off-peak (Figure 7). During a single cycle of operation extending from August 24 to August 26, 1990, the cold storage reservoir was fully charged, then fully discharged, demonstrating a maximum integrated cooling capacity of 27,643 ton-hours (349,993 MJ) and a figure of merit of 92.2% (Table 2).

Of particular significance is the small difference of 1.1°F (0.6°C) between the average outlet temperature during discharging and the average inlet temperature during charging, which directly measures the loss of integrated cooling capacity during storage. This result evidences little mixing below the thermocline zone during charging and is attributable to the low inertia of the inlet water as it is introduced into the cold storage reservoir (Wildin 1989).

Following completion of the commissioning phase on August 31, 1990, the operational phase commenced on September 1, 1990, under the local electric utility's time-of-day rate option and with the system's control functions being performed automatically according to systematic, documented operating and maintenance procedures (Utesch 1990).

[8]A density current is a low-velocity, nonturbulent current that moves horizontally across the cold storage reservoir's floor and gently displaces the less dense ambient water upward.

[9]A flow splitter is a "bull's-head" tee that equally divides a single incoming flow stream into two outgoing flow streams traveling in opposite directions.

[10]Viscous pressure drops and static pressure gains inside a diffuser pipe are both proportional to the dynamic pressure at its inlet. Hence, it is desirable to reduce this pressure in order to achieve uniform static pressure inside the diffuser pipe.

[11]The success of the project's commissioning phase was largely attributable to (1) review of designs, specifications, shop drawings, and submittal data; (2) preparation of operating and maintenance instructions; (3) inspection of equipment, materials, and work-in-progress; (4) operator training; and (5) functional performance testing of components and controls—all completed in advance of start-up.

TABLE 2
System Thermal Performance[1]

Parameter	Charge Cycle	Discharge Cycle
Duration	894 min	863 min
High Flow Rate	4,632 gpm (292 L/s)	4,159 gpm (262 L/s)
Low Flow Rate	314 gpm (20 L/s)	2,661 gpm (168 L/s)
Avg. Flow Rate	3,243 gpm (205 L/s)	3,071 gpm (194 L/s)
Total Flow	2,899,254 gal (10,998 m³)	2,650,464 gal (10,045 m³)
% Tank Volume	108.1%	98.9%
Start Inlet Temp.	50.5°F (10.3°C)	58.0°F (14.4°C)
End Inlet Temp.	38.2°F (3.4°C)	64.4°F (18.0°C)
Avg. Inlet Temp.	41.2°F (5.1°C)	57.3°F (14.1°C)
Start Outlet Temp.	57.4°F (14.1°C)	42.1°F (5.6°C)
End Outlet Temp.	42.1°F (5.6°C)	57.2°F (14.0°C)
Avg. Outlet Temp.	56.0°F (13.3°C)	42.3°F (5.7°C)
Avg. Temp. Diff.	14.8°F (8.2°C)	15.0°F (8.3°C)
Avg. Energy Rate	2,001 tons (7,038 kJ/s)	1,922 tons (6,760 kJ/s)
Total Energy	29,813 ton-hours (367,339 MJ)	27,633 ton-hours (349,993 MJ)

Cycle Thermal Efficiency = 27,633/29,813 = 92.7%
Figure of Merit = (27,633 x 12,000)/(2,680,904 x 8.33 x 1.0 x (57.3 – 41.2)) = 92.2%

[1]This thermal performance test was conducted during a single cycle of operation extending from August 24 to August 26, 1990, midway through the system's commissioning phase. As of that weekend, certain control functions were still being performed manually. Also, data were taken at varying intervals rather than continuously. Despite these ambiguities, the results indicate that the system stratified well and produced better-than-expected thermal performance.

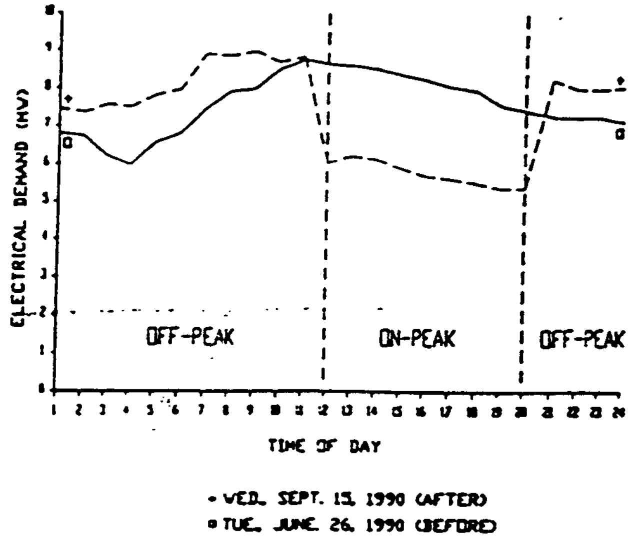


Figure 7 Electrical demand

DISCHARGING

During full-load cooling conditions, discharging commences shortly before 12:00 noon daily (Figure 8). All four chillers and all of their auxiliary equipment are turned off and just two 40-hp (29.8-kJ/s) constant-speed transfer pumps, one 40-hp (29.8-kJ/s) variable-speed distribution pump serving Zone 1, and one 100-hp (74.6-kJ/s) variable-speed distribution pump serving Zone 2 are operated to meet the facility's on-peak cooling load, which ranged from 2,528 to 2,800 tons (8,891 to 9,848 kJ/s) and totaled 21,248 ton-hours (269,025 MJ) on July 17, 1989. Thus, at full-load, total pumping energy for the facility totals only 0.06 kW (e) per ton (0.02 kW [e] per kJ/s). The digitally controlled pressure-sustaining valve in the line transferring warm water to the cold storage reservoir (PSV-1) is active and automatically modulates to vary the secondary supply temperature from 45° to 52°F (7.2° to 11.1°C) in order to maintain the secondary return temperature at a setpoint of 56.0°F (13.3°C).[12]

For example, if the secondary return temperature drops to 55°F (12.8°C), a –1.0°F (–0.6°C) deviation from its setpoint, PSV-1 closes slightly, raising the system's sustaining pressure and throttling the constant-speed transfer pumps—consistent with the transfer pumps' common cut-off and run-out pressure limits. This reduces the flow of 41°F (5.0°C) cold water from the cold storage reservoir and causes more of the warm water returning from the secondary system to recirculate into the suction of the secondary distribution pumps via the one-way crossover line. In this manner, the temperature of the blended water entering the secondary system is "floated"—consistent with maintaining

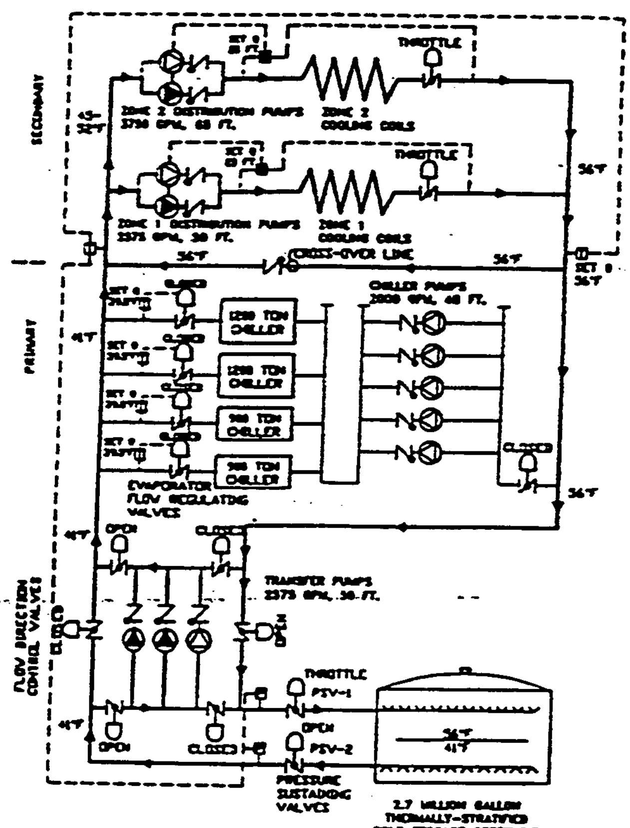


Figure 8 Discharging cycle

[12]As a result of testing, adjusting, and balancing of the secondary distribution system during the commissioning phase, the secondary return water temperature setpoint was raised from its design value of 56.0°F (13.3°C) to an operating value of 57.5°F (14.2°C) with no adverse consequences.

space temperature and humidity limits—in order to raise the secondary return temperature back to its setpoint.

To preclude "hunting," the control algorithm only adjusts the secondary supply temperature by −50% of the deviation between the secondary return temperature and its setpoint. In the example given, the adjustment to the secondary supply temperature would be −0.5 times −1.0°F (−0.6°C) equals +0.5°F (+0.3°C). Also, after an adjustment to the secondary supply temperature is made, a five-minute delay is imposed to allow the warmer blended water to circulate entirely through the secondary system and cause the secondary return temperature to rise. Thus, this interactive flow control method not only synchronizes primary/secondary flow rates, but it also ensures a constant secondary return temperature, even at part-load cooling conditions. Furthermore, it minimizes the flow rate of 41°F (5.0°C) cold water from the cold storage reservoir, thereby extending the discharge cycle.

CHARGING

During full-load cooling conditions, charging commences shortly after 8:00 p.m. daily (Figure 9). All four chillers and all of their auxiliary equipment, less designated back-up chilled-water and condenser cooling water pumps, are operated in order to simultaneously meet the facility's off-peak cooling load, which ranged from 1,980 to 2,601 tons (6,964 to 9,148 kJ/s) and totaled 34,790 ton-hours (440,483 MJ) on July 17, 1989, as well as to regenerate the cold storage reservoir for the next day's on-peak cooling load, which totaled 21,248 ton-hours (269,025 MJ) on July 17, 1989. Allowing 1% for storage reservoir and transfer pump heat gains, the facility's 4,200-ton (14,771-kJ/s) central chiller plant must operate at an average load of 3,516 tons (12,366 kJ/s) during the 16-hour charge cycle. Or, if the facility's 4,200-ton (14,771-kJ/s) central chiller plant is continuously operated at full load, the charge cycle can be completed in 13.4 hours.

The latter method of charging was adopted because it consumed less total energy. That is, although the amount of cooling produced by the chillers is equal, the amount of energy consumed by the auxiliary equipment is 16.3% less. This is accomplished by setting each chiller's control panel to maintain an evaporator leaving temperature of 38.0°F (3.3°C) and externally throttling each chiller's evaporator flow rate to maintain an evaporator leaving temperature of 39.5°F (4.2°C)—consistent with each evaporator's minimum and maximum flow rate limits.

In operation, the evaporators' leaving temperatures remain at 39.5°F (4.2°C) and the chillers cannot satisfy their internal setpoints of 38.0°F (3.3°C). As a result, their inlet guide vanes remain fully open, and they operate at 100% of capacity throughout the charge cycle. As the evaporators' common entering temperature and the condensers' common entering temperature vary during charging, the digitally controlled, evaporator flow-throttling valves automatically modulate to maintain each evaporator's leaving temperature at 39.5°F (4.2°C), thus preventing the chillers from unloading. This method of chiller operation is, therefore, not only more efficient than the part-load method, but it also provides a more constant evaporator leaving temperature.

Also, division of the 39.5°F (4.2°C) flow leaving the evaporators is synchronized between the secondary system and the cold storage reservoir using the same interactive flow control method as described for discharging, with the only difference being that the active pressure-sustaining

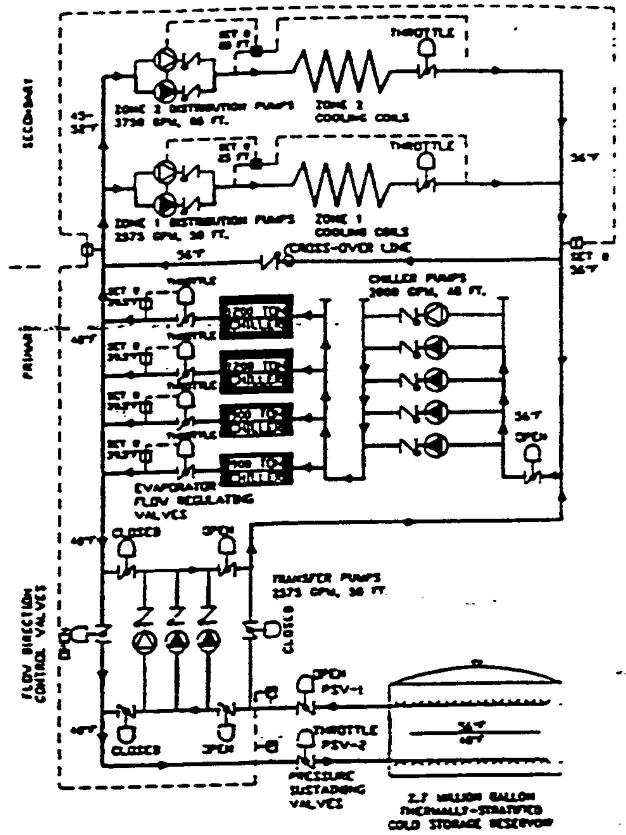


Figure 9 Charging cycle

valve (PSV-2) is in the line transferring cold water to the cold storage reservoir. This maximizes the flow rate of 39.5°F (4.2°C) cold water to the cold storage reservoir, thereby shortening the charge cycle.

SWITCHING OVER

Switching over between cycles is accomplished by six digitally actuated flow-direction control valves installed in the transfer pump suction/discharge/bypass manifold, as well as one digitally actuated flow-direction control valve installed in the chiller pump suction header (Figures 8 and 9). For this large-diameter, fail-safe application, pneumatic actuators were more reliable and much less expensive than electric actuators. Based thereon, butterfly valves with pneumatic scotch-yoke actuators having fail-safe air reservoirs were specified for flow-direction control. Also, two electronic limit switches were installed on each flow-direction control valve in order to provide positive feedback of valve position to the control system.

These valves automatically reverse the direction of flow in the lines transferring warm and cold water to and from the cold storage reservoir by opening or closing, as appropriate, in a prescribed "combination" that precludes hydraulic shock or loss of system-sustaining pressure. Also, the active pressure-sustaining valve becomes fully open and the fully open pressure-sustaining valve becomes active during cycle switch-over.

During switch-over from the charge cycle to the discharge cycle, flow direction to and from the cold storage reservoir is reversed before the central chiller plant is shut off. Conversely, during switch-over from the discharge cycle to the charge cycle, the central chiller plant is started

up before flow direction to and from the cold storage reservoir is reversed. Thus, in the event a flow-direction control valve malfunctions, the secondary system's supply of cold water is uninterrupted. Also, this method of switching over avoids starting and stopping transfer pumps during cycle switch-over and requires only a single set of three transfer pumps (Figure 10), each sized at 50% of required capacity, with one designated as a dedicated backup.

PART-LOAD OPERATION

Because the facility has cleanrooms, computer rooms, manufacturing equipment (e.g., vapor degreasers), and facility equipment (e.g., compressed air aftercoolers) that require continuous cooling, its daytime cooling loads average 1,242 tons (4,368 kJ/s)/9,941 ton-hours (125,865 MJ) from October to May.[13] Thus, year-round operation of the chilled-water thermal energy storage system is feasible and is practiced in order to reduce annual energy consumption as well as peak electrical demand.

Beginning on October 1, 1990, the inlet water temperature to the cold storage reservoir during charging was raised from 39.5°F (4.2°C) to 42.5°F (5.8°C), increasing chiller capacity by approximately 5%. Also, by operating with 70.0°F (21.1°C) condenser cooling water at part-load cooling conditions, rather than 83.0°F (28.3°C) condenser cooling water at full-load cooling conditions, chiller capacity was increased by an additional increment of approximately 6%. Thus, all four chillers and all of their auxiliary equipment were not needed to simultaneously meet the facility's reduced nighttime cooling load as well as regenerate the cold storage reservoir for the next day's reduced daytime cooling load.

Also, beginning on October 1, 1990, rather than commencing the charge cycle shortly after 8:00 p.m. daily, as was the practice during full-load cooling conditions, start of the charge cycle was delayed until nearly all of the cold water in the cold storage reservoir was depleted. Thus, the discharge cycle typically totaled 10 to 14 hours during part-load cooling conditions, rather than only 8 to 10 hours during full-load cooling conditions.

CONCLUSIONS

In the application studied, naturally stratified chilled-water thermal energy storage has proved to be a viable, cost-effective means of reducing the facility's annual electric costs and offsetting anticipated electric rate increases. The system's cost, schedule, performance, reliability, and profitability have all exceeded expectations, with the last criterion being boosted by the impact of nuclear generating station construction costs on the demand charge as well as the sensitivity of the energy charge to load factor improvements. Also, several advances in water storage tank construction, diffuser design and performance, plant interface methods, system commissioning practices, system operating strategies, and flow/temperature control techniques have been demonstrated. Finally, the importance of sound planning, good design, committed management, and proper commissioning, operation, and maintenance in successful thermal energy storage has been underscored.

[13] The facility's air-conditioned spaces are equipped with fan coil air-handling units that have digitally controlled outdoor air economy cooling cycles. As a result, the facility does not utilize chilled water for space conditioning when outdoor air conditions favor economy cooling.

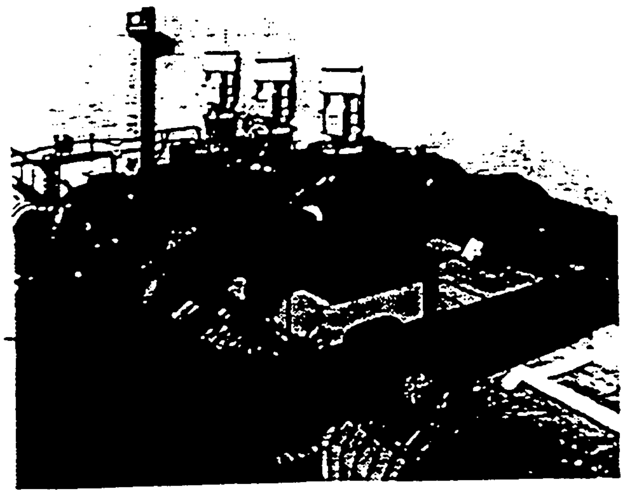


Figure 10 Transfer pumps

ACKNOWLEDGMENTS

The author would like to acknowledge the considerable assistance he received from Mr. Ian Mackie of Mackie Associates, Mr. Robert Tackett of TU Electric, Mr. A.L. Utesch of Cybernetic Systems Management, Mr. Ronald Wendland of the Electric Power Research Institute, and Dr. Maurice "Bud" Wildin of the University of New Mexico during the course of this project.

BIBLIOGRAPHY

ACI. 1988. "Committee 344 report on design and construction of circular wire and strand-wrapped prestressed concrete structures." Detroit, MI: American Concrete Institute.

ASHRAE. 1987. *ASHRAE handbook—1987 HVAC systems and applications*, ch. 46. Atlanta: American Society of Heating, Refrigerating, and Air-Conditioning Engineers, Inc.

ASHRAE. 1989. ASHRAE Guideline 1-1989, "Guideline for commissioning of HVAC systems." Atlanta: American Society of Heating, Refrigerating, and Air-Conditioning Engineers, Inc.

AWWA. 1987. ANSI/AWWA Standard D110-86 for wire wound circular prestressed-concrete water tanks. Denver, CO: American Water Works Association.

Hansen, E.G. 1985. *Hydronic system design and operation*. New York: McGraw-Hill.

Hodge, B.K. 1985. *Analysis and design of energy systems*. Englewood Cliffs, NJ: Prentice-Hall.

King, R.C. 1967. Piping handbook, 5th ed. New York: McGraw-Hill.

Stratified chilled-water storage design guide. 1988. Reid, Crowther, & Partners and George Reaves Associates for Electric Power Research Institute, Palo Alto, CA.

Utesch, A.L. 1989. "Variable speed CW booster pumping." *Heating/Piping/Air Conditioning*, May, pp. 49-58.

Utesch, A.L. 1990. "Control of stratified chilled-water thermal storage systems." *ASHRAE Transactions*, Vol. 96, Part 1.

Westaway, C.R., and A.W. Loomis. 1981. *Cameron hydraulic data*, 16th ed. Woodcliff Lake, NJ: Ingersoll-Rand.

Wildin, M.W. 1989. "Performance of stratified vertical cylindrical thermal storage tanks, part II: Prototype tank." *ASHRAE Technical Data Bulletin, Cool Storage Applications*, pp. 73-82. Atlanta: American Society of Heating, Refrigerating, and Air-Conditioning Engineers, Inc.

Wildin, M.W., and C.R. Truman. 1986. *User manual for STRAT.UNM: A finite difference model of stratified thermal storage*. Albuquerque: Department of Mechanical Engineering, University of New Mexico.

Wildin, M.W., and C.R. Truman. 1988. "Performance of stratified vertical cylindrical thermal storage tanks and improved finite difference model of stratified thermal storage." Albuquerque: Department of Mechanical Engineering, University of New Mexico.

Wildin, M.W., and C.R. Truman. 1989. "Performance of stratified vertical cylindrical thermal storage tanks, part I: Scale model tank." *ASHRAE Technical Data Bulletin, Cool Storage Applications*, pp. 63-72. Atlanta: American Society of Heating, Refrigerating, and Air-Conditioning Engineers, Inc.

APPENDIX A

Double-Octagon Diffuser Design

Total Tank Plan Area

$3.1416 \times (105.5\ ft/2)^2 = 8,741.7\ ft^2$

Inner Octagon

Area Inside Inner Octagon

$8,761.7\ ft^2 \times 0.25 = 2,185.4\ ft^2$

Radial Distance to Elbow Joint of Inner Octagon

$(2,185.4\ ft^2/3.1416)^{1/2} = 26.4\ ft$

Perimeter Length of Inner Octagon

$8 \times 2 \times 26.4\ ft \times \sin 22.5° = 161.5\ ft$

Effective Diffuser Length (L) of Inner Octagon

$2 \times 161.5\ ft = 323.0\ ft$

Maximum Volume Flow Rate (Q) of Inner Octagon

$5,120\ gal/min/(60\ s/min \times 7.48\ ft^3/gal \times 2) = 5.71\ ft^3/s$

Volume Flow Rate per Unit Diffuser Length (q) of Inner Octagon

$5.71\ ft^3/s/323.0\ ft = 0.0177\ ft^2/s$

Inlet Reynolds Number (Re_i) of Inner Octagon

$0.0177\ ft^2/s/0.000016576\ ft^2/s = 1,068$

Minimum Inlet Opening Height (h_i) of Inner Octagon to Yield an Inlet Froude Number (Fr_i) of 1.0

$(0.0177\ ft^2/s/1.0)^{2/3}/(32.17\ ft/s^2 \times (62.42630\ lb/ft^3 - 62.38641\ lb/ft^3)/62.38641\ lb/ft^3)^{1/3} = 0.25\ ft$[1]

Outer Octagon

Area Inside Outer Octagon

$8,761.7\ ft^2 \times (1.0 - 0.25) = 6,570.5\ ft^2$

Radial Distance to Elbow of Outer Octagon

$(6,570.5\ ft^2/3.1416)^{1/2} = 45.7\ ft$

Perimeter Length of Outer Octagon

$8 \times 2 \times 45.7\ ft \times \sin 22.5° = 279.3\ ft$

Effective Diffuser Length (L) of Outer Octagon

$2 \times 279.3\ ft = 558.6\ ft$

Maximum Volume Flow Rate (Q) of Outer Octagon

$5,120\ gal/min/(60\ s/min \times 7.48\ ft^3/gal \times 2) = 5.71\ ft^3/s$

Volume Flow Rate per Unit Diffuser Length (q) of Outer Octagon

$5.71\ ft^3/s/558.6\ ft = 0.0102\ ft^2/s$

Inlet Reynolds Number (Re_i) of Outer Octagon

$0.0102\ ft^2/s/0.000016576\ ft^2/s = 615$

Inlet Froude Number (Fr_i) of Outer Octagon with a Minimum Inlet Opening Height (h_i) of 0.47 ft[1]

$0.0102\ ft^2/s/(32.17\ ft/s^2 \times (0.47\ ft)^3 \times (62.42630\ lb/ft^3 - 62.38641\ lb/ft^3)/62.38641\ lb/ft^3)^{1/2} = 0.22$

[1]For ease of installation, the inlet opening heights (h_i) of the inner and outer octagons were both set at 0.47 ft.

APPENDIX B

Lateral-Slot-Shaped-Openings Design

Maximum Volume Flow Rate (Q) of Each Linear Diffuser Pipe

$5,120\ gal/min/(60\ s/min \times 7.48\ ft^3/gal \times 16) = 0.71\ ft^3/s$

Inner Octagon

Length of Each Linear Diffuser Pipe in Inner Octagon

$161.5\ ft/8 = 20.2\ ft$

Spacing between Openings along Each Linear Diffuser Pipe in Inner Octagon

0.5 ft[1]

Number of Openings along Each Linear Diffuser Pipe in Inner Octagon

$20.2\ ft \times 0.8/0.5\ ft = 32$[2]

Maximum Volume Flow Rate (Q) of Each Opening in Inner Octagon

$0.71\ ft^3/s/32 = 0.022\ ft^3/s$

Minimum Area of Each Opening in Inner Octagon to Yield a Maximum Outlet Velocity of 0.9 ft/s[3]

$0.022\ ft^3/s/0.9\ ft/s = 0.024\ ft^2$

Minimum Cross-Sectional Area of Each Linear Diffuser Pipe in Inner Octagon

$32 \times 0.024\ ft^2 = 0.77\ ft^2$ [4]

Length of Each Opening in Inner Octagon

$0.33 \times (12.75\ in. - (2 \times 0.406\ in.)) \times 3.1416/12\ in./ft = 1.03\ ft$

Minimum Width of Each Opening in Inner Octagon to Yield a Maximum Outlet Velocity of 0.9 ft/s

$0.024\ ft^2/1.03\ ft = 0.023\ ft$

Outer Octagon[5]

Length of Each Linear Diffuser Pipe in Outer Octagon

$279.3\ ft/8 = 34.9\ ft$

Spacing between Openings along Each Linear Diffuser Pipe in Outer Octagon

$34.9\ ft \times 0.8/32 = 0.87\ ft^2$

[1]This arbitrary selection was made to initiate the solution algorithm.
[2]A 20% allowance was taken to account for fittings and offsets that block out openings.
[3]This velocity was determined by scale-model testing conducted in a 325-gallon naturally stratified cylindrical stock tank.
[4]12-in.-diameter Schedule 40 PVC pipe, having an outer diameter of 12.75 in. and a wall thickness of 0.406 in., provides a cross-sectional area of 0.78 ft².
[5]For ease and economy of linear diffuser pipe fabrication, the pipe and opening sizes determined for the inner octagon were adopted for the outer octagon. Thus, only the lengths of the linear diffuser pipes and the spacing between the slot-shaped openings varied between the inner and outer octagons.

DISCUSSION

John S. Andrepont, Product Manager-Thermal Systems, Chicago Bridge & Iron Co., Oak Brook, IL: In light of the fact that the AWWA code for prestressed concrete tank construction permits up to 0.1% leakage per day (roughly 1 million gallons per year for your 2.7 million gallon tank) vs. *zero* leakage for welded-steel tanks, please comment on what special precautions, if any, were taken regarding selection of water treatment chemicals to minimize concerns of soil contamination.

D.P. Fiorino: Regarding leakage, our prestressed concrete chilled-water storage reservoir measured zero leakage during a leakage test conducted according to Section 4.13 of ANSI/AWWA Standard D110-86 in June 1990 and has measured zero leakage since. The overall result has been a cost-effective (less than $0.25 per gallon) and completely maintenance-free structure.

Regarding water treatment chemicals, we had employed a blended compound of silicate-based corrosion inhibitors, deposition controllers, and biofouling retarders at a concentration of 1,000 ppm and a pH of 8.5 for several years prior to installation of our prestressed concrete chilled-water storage reservoir and have continued this inexpensive and effective water treatment program since. Because silicate-based water treatment chemicals are nontoxic and nonhazardous, the chilled-water storage reservoir is not an EPA-regulated underground storage tank (UST) and special precautions relative to potential soil contamination were not required. And, because silicate-based water treatment chemicals are nonreactive with concrete, treatment of the prestressed concrete chilled-water storage reservoir's interior surfaces was not required.

Finally, one matter highly important to successful thermal energy storage in either prestressed concrete or welded steel chilled-water storage reservoirs is pre-operational cleaning. Effective removal of contaminants before start-up of a thermal energy storage system precludes a wide variety of future problems and failures. In the application under study, we employed the pre-operational cleaning procedures outlined in Table 4-1 of *Water Treatment Technologies for Thermal Storage Systems* 1987, Ahlgren Associates, for the Electric Power Research Institute, Palo Alto, CA.

Thermal Energy Storage Program for the 1990s

Donald P. Fiorino, P.E.
Texas Instruments, Inc.
P.O. Box 655474 - MS 311
Dallas, Texas 75265

Introduction

Texas Instruments has chilled water thermal energy storage systems in operation at two of its major defense electronics manufacturing facilities in North Texas. The first system was commissioned in August 1990 at a 10-year-old, 1.1 million sq ft Electro-Optics manufacturing facility in Dallas, Texas. Its capacity is 2,900 kW/2.7 million gal/24,500 ton-hours. The second system was commissioned in June 1992 at an eight-year-old, 1.2 million sq ft Avionics manufacturing facility in McKinney. Its capacity is 3,200 kW/3.1 million gal/28,800 ton-hours. This paper will discuss the objectives, strategy, method, design, operation, schedule, cost, return, and performance of the first system within the context of the energy cost outlook in North Texas as well as existing conditions at the retrofitted facility. In addition, this paper will describe improvements in operation of the first system as well as advancements in design of the second system.

Energy Cost Outlook

The energy cost outlook in North Texas is dominated by the 2,300 MW Comanche Peak Nuclear Generating Station. In mid-1989, when formal economic analysis of the first thermal energy storage system was being performed, Comanche Peak was more than 11 years behind schedule and was more than 10 times as expensive as originally estimated. Its two 1,150

MW nuclear generating units were scheduled to begin commercial operation separately—the first in 1990 and the second in 1992. Comanche Peak was then projected to cost $9.1 billion upon completion, and utility officials were planning to request separate 10% rate increases as each nuclear generating unit became operational. In fact, Comanche Peak Unit #1 did become operational in 1990, and the utility implemented a 10.2% bonded rate increase in August of that year. However, start-up of Comanche Peak Unit #2 has been delayed until 1993, and Comanche Peak is now projected to cost $10 billion-$11 billion when completed.

Characteristic of nuclear rate cases, a large percentage increase in the demand charge was necessary for the utility to recover the high fixed cost of its investment. In the case of Comanche Peak Unit #1, the demand charge for primary voltage customers increased 54% from $6.98/kW to $10.72/kW. Also characteristic of nuclear rate cases, the less expensive uranium fuel reduced the utility's fuel charge. In the case of Comanche Peak Unit #1, the fuel charge for primary voltage customers decreased 14% from $0.0215/kWh to $0.0186/kWh. Looking ahead, Comanche Peak Unit #2 is expected to result in a second increase in the demand charge and a second decrease in the fuel charge, both of approximately the same magnitude as Comanche Peak Unit #1.

Thus, from a customer's perspective, control of kilowatt demand has become much more important than before Comanche Peak while control of kilowatt hour usage has become somewhat less important. And, from the utility's perspective, demand-side management has become more important than before Comanche Peak while construction of expensive new generating capacity has become less important. In fact, a $1.4 billion disallowance by the Public Utility Commission of Texas in the Comanche Peak Unit #1 rate increase wiped out the utility's retained earnings and downgraded its debt rating, causing the utility to defer indefinitely construction of three planned generating stations.

Existing Conditions

The Electro-Optics manufacturing facility was a modular, one- and two-floor manufacturing complex having continuous operations and year-around cooling loads. Its annual energy usage was approximately 170,000 Btu/sq ft/yr. Cooling loads consisted of: (1) space air cooling/dehumidifying, e.g., assembly areas, cleanrooms, computer rooms; (2) outdoor air

cooling/dehumidifying to replace exhausted space air; and (3) water-cooled equipment, e.g., compressed air intercoolers and aftercoolers, refrigerant condensers on environmental test chambers, vapor condensing coils on solvent degreasers, etc. As a result of the above, the facility's electric and cooling demand factors were both approximately 75%. Also, the facility's peak cooling load was approximately 3,000 tons (2.6 tons/1000 sq ft) and its peak cooling kilowatt demand totaled approximately 33% of its peak kilowatt demand.

As for chilled water generation, the Electro-Optics manufacturing facility was equipped with a central chiller plant with parallel arrangements of high efficiency, electric-driven chillers, pumps, and cooling towers, with redundant chillers, pumps, and cooling towers for back-up. Its chillers consisted of four low pressure centrifugal machines having multi-stage, direct drive hermetic compressors, CFC-11 refrigerant, refrigerant economizers, and impeller inlet guide vanes. Installed chilling capacity totaled 4,200 tons, with one 1,200-ton chiller designated as a dedicated back-up.

Regarding chilled water distribution, the Electro-Optics manufacturing facility had a closed, variable flow, direct return chilled water piping network with five, 125-hp primary pumps in the primary return main immediately upstream of the chillers. Pressurization of 12 psig was applied at the suction of the primary pumps, and two primary sub-circuits were direct-connected to the primary supply and return mains. A secondary circuit (for equipment cooling) was physically and hydraulically separated from the primary circuit by a shell/tube heat exchanger. Primary supply temperature was maintained at 45°F, and secondary supply temperature was maintained at 75°F.

The Electro-Optics manufacturing facility's chilled water distribution system achieved its design temperature differential of 12°F (2 gpm/ton) at peak cooling loads but fell to as low as 8°F (3 gpm/ton) at partial cooling loads. Resulting imbalances between the facility's variable chilled water flow demand and the chillers' fixed evaporator flow limits were resolved by: (1) operating the chillers partly loaded with maximum evaporator flow rates and below-design evaporator temperature differentials; or (2) bypassing excess return water through the evaporator of an off-line chiller and reducing the evaporator outlet temperatures of the on-line chillers below 45°F in order to maintain a 45°F "blended" supply temperature. Also, the 125 hp primary pumps normally operated well to the right of their selection points.

Energy Management Objectives

After consideration of the energy cost outlook in North Texas and existing conditions in the Electro-Optics manufacturing facility, four energy management objectives were adopted. First, electricity costs, which accounted for more than 90% of total energy costs, needed to be reduced from levels in effect prior to the Comanche Peak Unit #1 rate case in order to reduce expenses and improve competitiveness. Second, both of the upcoming Comanche Peak rate increases needed to be entirely offset in order to maintain control of energy costs. Third, excess kilowatt hour usage related to live-load chiller plant operation needed to be reduced. Fourth, any capital project undertaken to accomplish the first three objectives needed to: (1) earn an attractive after-tax return with little risk; (2) have no adverse environmental impact; and (3) be consistent with future conversion of the existing chillers to HCFC-123 refrigerant.

Energy Management Strategy

Cogeneration, purchase of high voltage electricity, and thermal energy storage were evaluated for technical feasibility, economic attractiveness, and conformance to the energy management objectives outlined above. Cogeneration was unacceptable because of its combustion emissions and technically infeasible due to a lack of beneficial use for waste heat. Purchase of high voltage electricity was technically feasible, but was less economically attractive than thermal energy storage because of: (1) the need to purchase and install redundant transformers, transmission lines, switchgear, etc. in order to assure reliability; and (2) the large utility incentive payments offered to install thermal energy storage. Also, purchase of high voltage electricity would only partially offset the Comanche Peak Unit #2 rate increase and would do nothing to reduce excess kilowatt hour usage by the central chiller plant.

Having selected thermal energy storage as the best energy management alternative for the manufacturing facility, determining a strategy for its implementation was straight-forward. Simply put, all 2,900 kW of peak cooling demand would be shifted from peak demand periods, i.e., noon to 8:00 p.m., to off-peak demand periods, i.e., 8:00 p.m. to noon. A new thermally stratified chilled water storage reservoir would be interconnected with the facility's existing 4,200 ton central chiller plant in order to:

(1) minimize capital expenditures; and (2) simultaneously satisfy the facility's nighttime cooling load and recharge the thermal energy storage reservoir.

The large incentive payments and the favorable "Time-of-Day" rate option offered by the utility would be taken advantage of in order to reduce electricity costs. In addition, kilowatt demand savings from thermal energy storage would be "leveraged" by the large increases in the demand charge associated with each unit of Comanche Peak. Also, by operating the central chiller plant fully loaded at nighttime, excess kilowatt hour usage associated with live-load chiller plant operation would be eliminated. Furthermore, chilled water thermal energy storage using non-hazardous water treatment chemicals had no adverse environmental impact. Finally, chilled water thermal energy storage could tolerate the 5%-15% decrease in chiller capacity normally associated with conversion to HCFC-123 refrigerant with no adverse impact on integrated cooling capacity.

Thermal Energy Storage Method

Several factors favored thermally stratified chilled water storage in the first application. In addition to the availability of the existing 4,200 ton central chiller plant to generate and to distribute chilled water, the cost, efficiency, simplicity, reliability, and maintenance of a large thermally stratified chilled water storage reservoir were superior to either ice or eutectic salt storage alternatives.

Thus, a 2.7 million gal thermally stratified chilled water storage reservoir was designed to provide 24,500 ton-hours of integrated cooling capacity with a 15°F average discharge temperature differential and 90% usable volume for the Electro-Optics manufacturing facility. An AWWA Standard D110-86 (Type III) cylindrical precast, prestressed concrete water storage tank with an interior diameter of 105 ft - 6 in and a water capacity level of 41 ft was installed to meet the requirement. The tank was buried to the top of its circular wall, and its clear-span spherical dome roof was insulated with 2-in thick spray-on polyurethane foam, a butyl rubber vapor barrier, and a highly reflective white outer coating.

Its concentric ring diffuser system consisted of two octagons fabricated using 12-in diameter PVC pipe having 120° arc by 1/4-in wide lateral slot-shaped openings. Reynolds numbers of the concentric ring diffuser system were 1,068 for the inner octagon and 615 for the outer octagon. with a common inlet opening height of 5-5/8 in, the Froude numbers of the

concentric ring diffuser system were 0.38 for the inner octagon and 0.22 for the outer octagon.

Transfer pumps and piping were sized for 5,120 gpm and consisted of two 16-in diameter buried, pre-insulated, welded-steel pipes and three 40-hp vertical, split-case, centrifugal pumps, each sized for 2,575 gpm, with one designated as a dedicated back-up. Two-position pneumatic direction control valves with fail-safe air reservoirs and electronic end switches were installed to reverse flow direction between the chilled water storage reservoir and the central chiller plant during cycle switch-over. Also, two modulating pneumatic pressure-sustaining valves having fail safe air reservoirs were installed to continuously maintain 5 psig pressure at the highest point in the facility's chilled water distribution system.

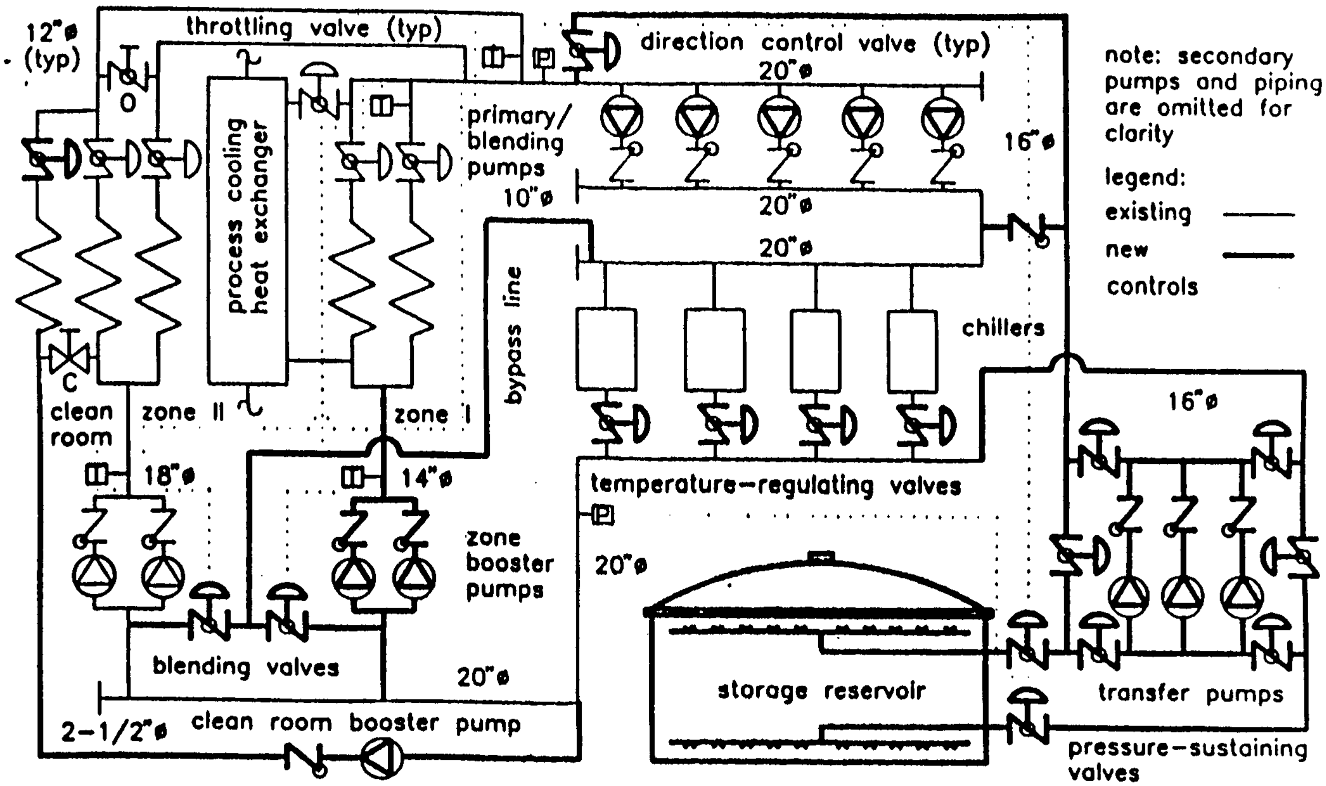
The Electro-Optics facility's existing chilled water distribution system was modified by installing pairs of variable speed booster pumps in the supply lines of each of the primary sub-circuits to automatically maintain individual sub-circuit differential pressure setpoints. In addition, cross-over piping was installed between the primary return main, downstream of the downsized 30-hp primary pumps and the suction lines of each pair of booster pumps. Modulating pneumatic temperature-regulating valves were installed in both branches of the crossover piping to "inject" warm return water into the suction lines of each pair of booster pumps. These valves automatically adjusted each primary sub-circuit's supply temperature in order to maintain individual return temperature setpoints and the latter were automatically reset based on outdoor air enthalpy.

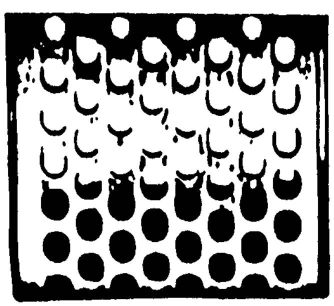
Lastly, a direct digital control system consisting of 70 input/output points, three distributed control panels, and a PC-based graphical monitor/operator interface was installed. Displays included the facility's hourly kilowatt demand profile, the storage reservoir's vertical temperature distribution, valve positions, flow rates, temperatures, pressures, etc. In addition, the control system calculated the integrated cooling capacity of the storage reservoir and continuously updated the operator as integrated cooling capacity was added during the charge cycle and withdrawn during the discharge cycle.

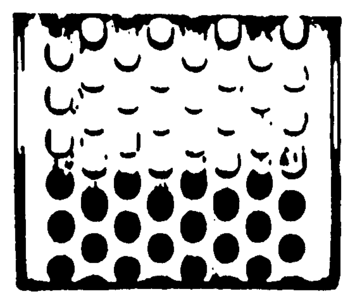
Thermal Energy Storage Operation

The thermally stratified chilled water storage system at the Electro-Optics manufacturing facility is operated to fully shift cooling kilowatt

Figure 1. Chilled water TES at TI's Electro-Optics facility.







demand to nighttime.

From 8:00 p.m. to noon daily, the facility's existing central chiller plant is operated to: (1) provide live-load chilling to satisfy the facility's nighttime cooling load; and (2) charge the chilled water storage reservoir. By setting the chillers' control panels for 38°F and modulating external pneumatic temperature-regulating valves to actually maintain each chiller's evaporator leaving water temperature at 39.5°F, the inlet guide vanes stay fully open and the compressors stay fully loaded throughout the charge cycle. Then, given: (1) consistently high evaporator inlet temperatures of 56°F-59°F because of automatic control of sub-circuit return temperatures during both the current nighttime charge cycle and the previous daytime discharge cycle; and (2) maximum condenser water flow at inlet temperatures ranging from 83°F to as low as 65°F because of nighttime cooling tower operation, the chillers consistently produce greater-than-design tonnage using design compressor kilowatt demand and design auxiliary equipment kilowatt demand.

From noon to 8:00 p.m. daily, the central chiller plant is entirely shut off, and the Electro-Optics facility's integrated daytime cooling load is satisfied by the chilled water storage reservoir. By: (1) automatically maintaining the sub-circuit flow rates no greater than necessary to satisfy each distribution zone's instantaneous cooling load and (2) automatically blending the sub-circuit supply temperatures to no colder than necessary to maintain each distribution zone's space humidity requirements, the facility's integrated daytime (and nighttime) cooling load is minimized. This reduces the withdrawal rate of cold water from the storage reservoir, thereby increasing thermal stratification effectiveness and reducing transfer pump kilowatt hour usage. It also assures a consistently high return temperature to the storage storage reservoir, thereby increasing integrated storage capacity and further increasing thermal stratification effectiveness.

Switch-over from charge-to-discharge and discharge-to-charge is automatically accomplished by reversing the positions of the direction control valves in a prescribed sequence that precludes hydraulic shock and avoids loss of system sustaining pressure. In this manner, the transfer pumps continue to operate without interruption. The operator initiates cycle switch-over and manually starts/stops the chillers and auxiliary equipment based on prompts and acknowledgements between himself and the PC-based monitor/operator interface. Using suitable prompts and acknowledgements, as well as positive feedback of proper positioning of

control valves, the operator and control system are able to switch over surprisingly fast and reliably.

Project Costs, Schedules, Returns, and Performance

The thermally stratified chilled water storage system had a gross cost of $1.67 million ($68/ton-hour). After two utility incentive payments totaling $610,500 ($25/ton-hour), the system's net cost totaled $1.06 million ($43/ton-hour). Construction began on October 26, 1989, and the system started up on August 13, 1990, 10-1/2 months after breaking ground and coincident with implementation of the Comanche Peak Unit #1 rate increase. Commissioning was completed in two weeks, and the system commenced operation under the utility's "Time-of-Day" rate option on September 1, 1990.

Savings totaled $221,000 during the system's first year of operation and consisted of $186,500 of kilowatt demand savings and $34,500 of kilowatt hour usage savings. Annual kilowatt demand savings are projected to escalate to $251,600 after implementation of the Comanche Peak Unit #2 rate increase in 1993, increasing total annual savings to $286,100. Thus, simple payback of the project's net cost will occur within five years.

To date, the system has been 100% reliable in shifting peak cooling kilowatt demand to nighttime and has reduced annual cooling kilowatt hour usage by approximately 1,380,000 kWh or 12%. The former result is attributable to adequate design margins, simple system operation, and thorough system commissioning—including operator training and written operation/maintenance/emergency instructions. The latter result is attributable to full-load chiller operation year-around with reduced condenser water inlet temperatures and elevated evaporator water inlet temperatures, reduced (charge cycle) and eliminated (discharge cycle) evaporator pressure drops, improved flow/temperature control in the primary sub-circuits, and negligible storage reservoir heat gains.

Operating Improvements

Subsequent improvements in operation of the thermally stratified chilled water storage system at the Electro-Optics manufacturing facility have included an integrated indirect evaporative chilling/condenser water

heat recovery/demand-limiting partial-discharge operating strategy between mid-October and mid-March.

Making use of a spare 630-ton counterflow, forced-draft cooling tower and a spare 1,800 sq ft shell/tube heat exchanger allowed for indirect evaporative chilling of the 56°F-59°F warm water as it returned from the facility's chilled water distribution system to the top of the chilled water storage reservoir during the discharge cycle. This sub-strategy's coefficient-of-performance ranges from 5.0 when the outdoor wet-bulb temperature is 51°F to as high as 22.6 when the outdoor air wet-bulb temperature is 17°F, making it more efficient than operating a centrifugal chiller and its auxiliary equipment. The indirect evaporative chilling sub-strategy operates approximately 3,500 hr/yr and produces approximately 1.1 million ton-hr/yr of "free" chilling.

The remainder of the integrated wintertime operating strategy involves continuously operating the thermal energy storage system in a partial-discharge cycle, with one centrifugal chiller and its auxiliary equipment operating with an elevated evaporator water outlet temperature in the heat recovery mode and the indirect evaporative chilling sub-strategy enabled whenever the outdoor air wet-bulb temperature is 51°F or below. This strategy elevates the chiller's coefficient-of-performance from 5-6 (cooling only) to 7-9 (heating and cooling) and makes operation of the facility's 400-hp hot water boiler unnecessary. In fact, the hot water boiler has been decommissioned, entirely eliminating facility natural gas usage and emissions. Also, the facility's oversized constant speed hot water pumps, oversized heating coils, and pneumatic hot water valves with limited spring closing force provide much better control with 95°F inlet water (using condenser waste heat) than with 180°F inlet water (using boiler heat). Finally, continuous operation of one centrifugal chiller and its auxiliary equipment levels the facility's wintertime kilowatt demand, yielding additional kilowatt demand savings.

Design Advancements

Several technical advancements were incorporated in to the design of the second, larger thermally stratified chilled water storage system at the Avionics manufacturing facility. First, because the evaporators of the chillers at the Avionics manufacturing facility were selected for 2.4 gpm/

ton, rather than 2.0 gpm/ton as at the Electro-Optics manufacturing facility, series chiller operation was feasible and yielded greater capacity and efficiency than parallel chiller operation. In addition, the Avionics manufacturing facility's equipment cooling load was served in series with, rather than in parallel with, the facility's space and outdoor air cooling/dehumidifying loads, yielding a higher return temperature and all of the associated operating advantages. Also, variable speed, rather than constant speed, transfer, primary, and blending pumps were selected in order to improve controllability and minimize pumping kilowatt hour usage year-around. Finally, piping to a large, existing plate/frame heat exchanger was modified to provide indirect evaporative chilling whenever the outdoor air wet-bulb temperature is 51°F or below (approximately 3,500 hr/yr between mid-October and mid-March).

Conclusions

The thermal energy storage program described was implemented with due consideration given to the energy cost outlook in North Texas as well as existing conditions in the retrofitted facilities. It now exceeds 50,000 ton-hours in integrated storage capacity and has established a solid record of efficiency, performance, profitability, and reliability. Although several of its design features and operating strategies are at the leading edge of thermal energy storage practice, the program's success to date rests largely on fundamentals such as thorough analysis, sound planning, good design, and effective operation and maintenance.

About the Author

Donald P. Fiorino is a facility engineer and member of the group technical staff at Texas Instruments Inc., Dallas. He received his B.S. in engineering science from the U.S. Military Academy at West Point and his M.S. in industrial engineering from the University of Texas at Arlington. Fiorino serves on the National Advisory Council for the Thermal Storage Applications Research Center at the University of Wisconsin at Madison. The TES project at TI's Electro-Optics manufacturing facility received AEE's 1991 Energy Project of the Year Award.

FOREST LANE

THERMAL ENERGY STORAGE

BEFORE VS. AFTER ENERGY COSTS

($000)

12 MONTHS BEFORE:	JAN90	FEB90	MAR90	APR90	MAY90	JUN90	JUL90	AUG89	SEP89	OCT89	NOV89	DEC89	YEAR
ELEC. BILL	203.0	184.3	185.8	204.6	190.0	205.4	212.6	201.9	204.1	189.9	194.1	211.6	2387.3
Comanche Peak C/P UNIT #1	5.9	5.3	5.4	5.9	5.5	6.0	6.2	5.9	5.9	5.5	5.6	6.1	69.2
GAS BILL	7.4	6.5	1.2	1.7	0.2	0.2	0.2	0.3	0.2	2.6	2.8	7.6	30.9
ENERGY BILL	216.3	196.1	192.4	212.2	195.7	211.6	219.0	208.1	210.2	198.0	202.5	225.3	2487.4
LAST 12 MONTHS:	JAN92	FEB92	MAR92	APR92	MAY92	JUN92	JUL92	AUG92	SEP92	OCT91	NOV91	DEC91	YEAR
ELEC. BILL	174.9	173.0	173.8	182.9	178.0	183.4	192.0	186.5	183.1	178.8	179.9	175.6	2161.9
GAS BILL	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	2.4
ENERGY BILL	175.1	173.2	174.0	183.1	178.2	183.6	192.2	186.7	183.3	179.0	180.1	175.8	2164.3
ACTUAL SAVINGS:	41.2	22.9	18.4	29.1	17.5	28.0	26.8	21.4	26.9	19.0	22.4	49.5	323.1
Projected PROJ. SAVINGS:	12.3	12.4	12.0	12.9	14.6	15.4	17.7	18.2	19.0	17.1	13.1	13.0	177.7
EXTRA SAVINGS:	28.9	10.5	6.4	16.2	2.9	12.6	9.1	3.2	7.9	1.9	9.3	36.5	145.4
% EXTRA SAVINGS:	235.0%	84.7%	53.3%	125.6%	19.9%	81.8%	51.4%	17.7%	41.6%	11.1%	71.0%	280.8%	81.8

APPENDIX 4I

BROCHURE AND PROPOSAL FOR CONCRETE CHILLED WATER STORAGE TANK

NATGUN
PRECAST
PRESTRESSED
PREFERRED

Established 1929

Natgun Corporation
Precast Concrete Tanks
11 Teal Road
Wakefield, MA 01880-1292
Telephone 617-246-1133
FAX 617-245-3279

March 3, 1993

Ms. Kelly Winett
Engineer Resource Group
158 Business Center Drive
Birmingham, AL 35244

Reference: TES Tank
Lyster Army Community Hospital

Dear Ms. Winett:

As discussed during our telephone conversation, based on 1992 construction costs, suitable budget estimating figures for the design and construction in the Birmingham, Alabama area of a 1.0 MG Thermal Energy Storage tank is approximately $550,000; a 0.5 MG Thermal Energy Storage tank is approximately $413,270; and a 0.2 MG Thermal Energy Storage tank is approximately $260,320. These figures include internal diffuser piping, exterior insulation (with protective coating), dome with hatch and vent, and foundation.

These prices do not include earth excavation, rock excavation, backfill, dewatering systems, underdrain, or landscaping. A rough preliminary breakdown for these budget figures are as follows:

TANK SIZE	1.0 MG	0.5 MG	0.2 MG
DIMENSIONS	(70'd x 35'h)	(55.5'd x 28'h)	(41'd x 20.5'h)
TANK	$450,000	$355,000	$230,000
INSULATION	60,000	37,270	20,320
DIFFUSER	40,000	21,000	10,000
TOTAL	$555,000	$413,270	$260,320

The above prices are for a naturally stratified, prestressed, precast, concrete storage tank to be constructed at existing grade. If the tank can be buried, partially or fully, the backfill can be utilized as insulation thereby reducing the cost of applying complete insulation of the tank; this cost may be

Southwest Office: Suite 701 8111 Preston Road Dallas, TX 75225-6307 Telephone 214-368-3306
Midwest Office: Suite 310 1580 S. Milwaukee Avenue Libertyville, IL 60048-3773 Telephone 708-816-84[illegible]

significant. Various dimensions can be utilized for the tank sizes; I have used the height-diameter ratio of approximately 0.50, which appears to be an efficient design. A Natgun prestressed, precast, concrete Thermal Energy Storage tank requires virtually no maintenance.

If you require any additional information or have any questions, please contact the writer at your convenience.

Conservation is Power for the future.

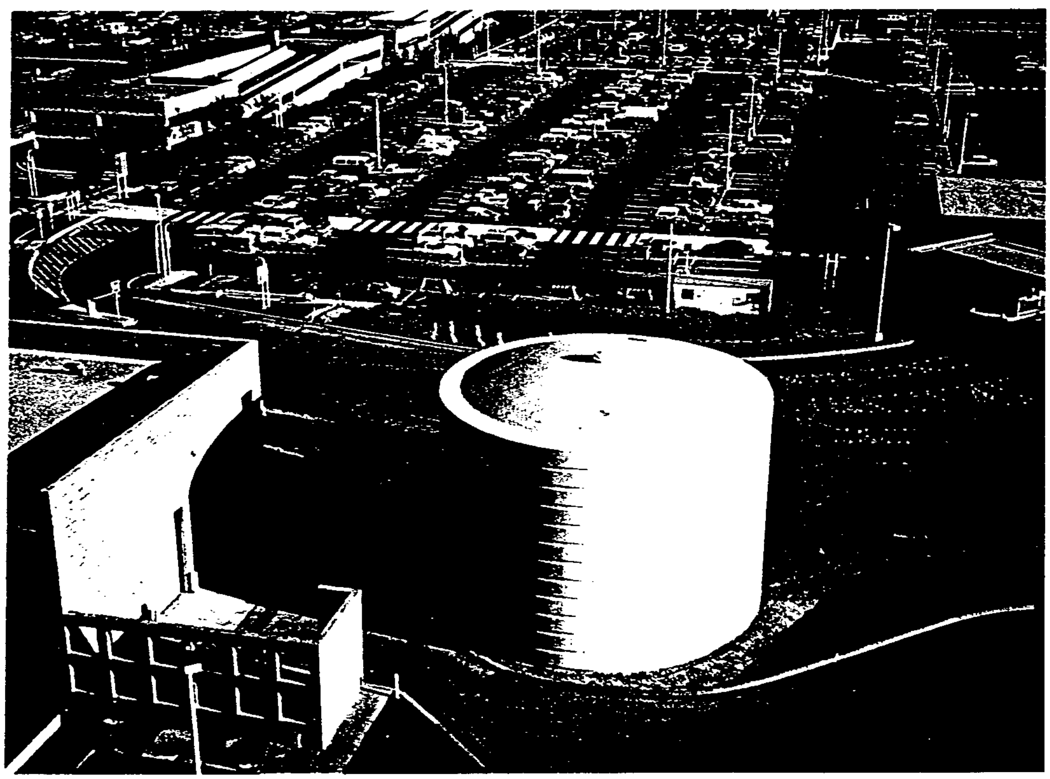
Very truly yours,

NATGUN CORPORATION

Frederick A. McDonough, Jr.
Vice President - Construction

FAM/djh

HOW TO PUT A CHILL ON RISING ENERGY COSTS



0.55 MG Thermal Storage Tank for the San Antonio, Texas Airport.

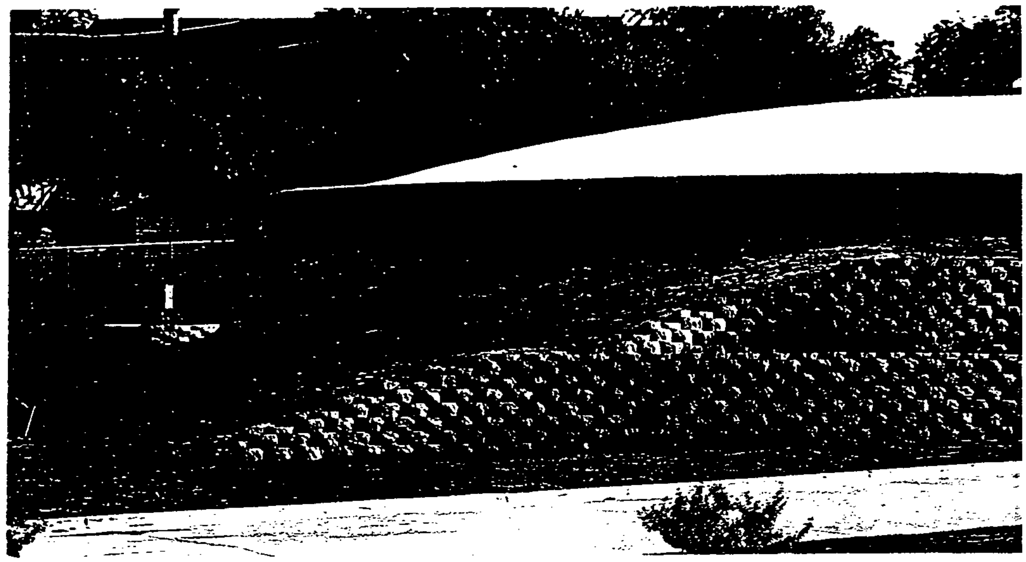
NATG

N PRECAST
PRESTRESSED
PREFERRED

THERMAL STORAGE TANKS SAVE HU

The natural forces which cause the deeper layers of water in a still lake or pond to remain the coldest have a lot to do with the way more and more companies are saving hundreds of thousands of dollars per year on their electric bills.

It's naturally-stratified chilled water storage, a proven technology for keeping layers of warm and cold water separated in a single storage tank — and a proven method for companies to lower electric costs each year at every one of their facilities equipped with chilled water air conditioning systems. For many large industrial plants and commercial buildings, savings of hundreds of thousands of dollars per year are possible.



Partially buried 2.7 MG Chilled Water Storage Tank for Texas Instr

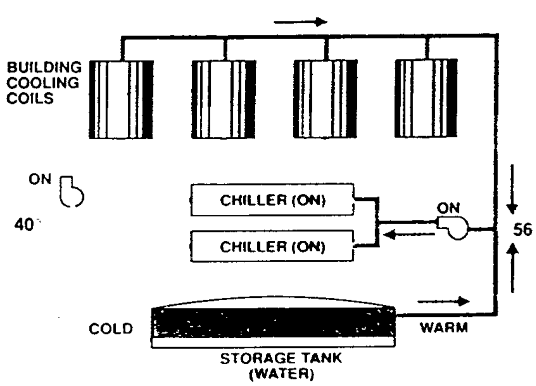
As electric rates continue to increase, large users and utilities alike are being challenged to manage kilowatt demand. More and more, in both moderate and hot climates, their most cost-effective option is thermal storage.

Here's how thermal storage saves money in a typical air conditioning installation:

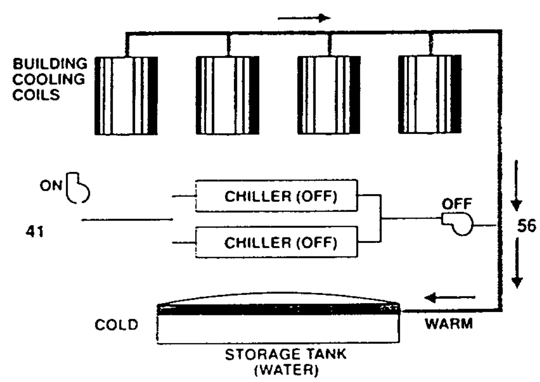
Using a prestressed concrete storage reservoir (see diagram), a facility produces chilled water at night, during the local utility's "off-peak" period. The following day, during the utility's "on-peak" period, the chiller plant is turned off and the facility is cooled by withdrawing cold water from the bottom of the thermal storage reservoir. The company saves money in four ways:

1- Reduced Demand Charges By operating its chiller plant only during the local utility's off-peak period, a facility's on-peak demand is reduced by up to 40%, yielding significant

HOW THERMAL STORAGE WORKS

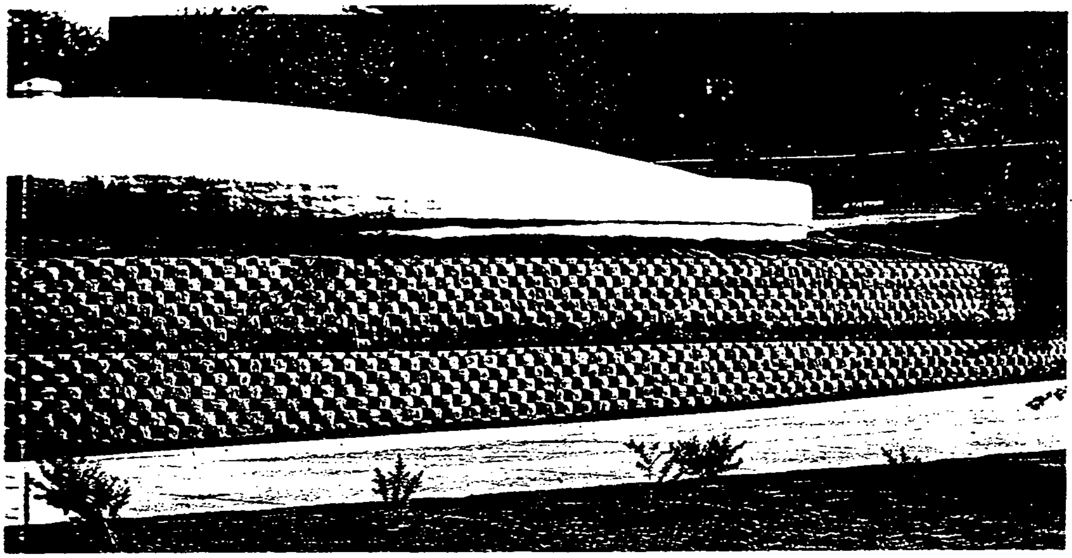


Off-Peak Cooling Mode The water storage tank is "charged" with cold water at night using chillers, cooling towers, and associated pumps to take advantage of lower electric usage rates.



Peak Cooling Mode During the day, cold water is withdrawn from the bottom of the tank, providing the building with air conditioning. Chillers, cooling towers, and associated pumps are turned off, thus reducing electric power demand.

NDREDS OF THOUSANDS OF DOLLARS.



ruments, Inc., Dallas Texas. Engineered by Texas Instruments, Inc.

annual savings in demand charges.

2- Lower Usage Rates Off-peak usage rates are lower than on-peak usage rates. These lower rates can take the form of downwardly sliding price scales or discounts off the utility's standard off-peak usage rate.

3- Shared Construction Costs Because thermal storage helps postpone or avoid construction of expensive new generating stations, most electric utilities offer major cash incentives to companies installing thermal storage systems. These incentives are usually based on the amount of kilowatt demand that will be shifted from on-peak to off-peak. Many electric utilities also share the cost of an engineering study to assess the feasibility and profitability of a thermal storage installation.

4- Fewer Equipment Purchases In both new construction and facility expansion projects, it is often possible to substitute a thermal storage tank for some or all of the chiller plant equipment that would otherwise need to be purchased. Current capital outlays and future operating costs are both reduced, yielding significant energy cost savings for years to come.

BUT DON'T JUST TAKE OUR WORD FOR IT.

Here's what Mr. Don Fiorino, Facility Engineer for Texas Instruments in Dallas, Texas wrote about the Natgun thermal storage tank pictured above.

"This 24,500 ton-hour thermal energy storage system utilizes a precast, prestressed concrete tank to store chilled water. It was installed as a retrofit project in just 10.5 months at a total cost of $68 per ton-hour (62¢ per gallon). Since start-up in August, 1990, it's performance has exceeded our expectations. In particular, we've enjoyed 100% reliability, 92.7% cycle thermal efficiency, 34% greater savings than projected, and 13% greater capacity than designed.

"In addition to reducing our on-peak electric demand by 2,300 kW, as projected, we have reduced electric usage by an average of 175,000 kWh per month, or 3.7%.

"First-month savings on our electric bill were $25,256. Present annual savings are now calculated at about $241,000, rising to approximately $340,000 by the year 1993

WHY PRESTRESSED CONCRETE MAKES THE BEST THERMAL STORAGE TANK

There are two commonly accepted materials for constructing watertight storage tanks — prestressed concrete and steel. Today, tank users specify prestressed concrete for its minimal maintenance, rapid construction time, and lower long-term cost.

Prestressed concrete is preferred for thermal storage systems over steel tanks for several important reasons:

1- **Higher R Rating** Concrete has a higher R rating than steel.

2- **Siting Options** Prestressed concrete can be totally or partially buried. In such cases the R rating advantage over steel is even further increased.

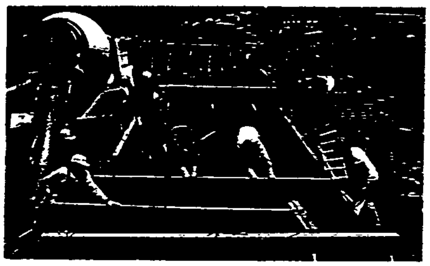
3- **No Routine Maintenance** Because they rust, steel tanks must be periodically drained and taken out of service to be maintained, usually in the summer months when the system is needed most. No such problems with prestressed concrete.

Moreover, prestressed concrete eliminates the need for corrosion protection where the tank wall comes in contact with additional insulation that may be installed.

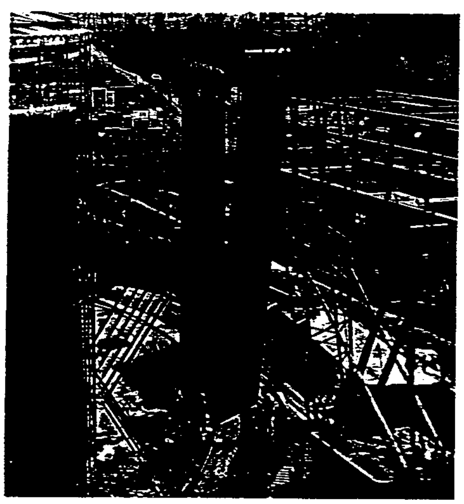
4- **Decades of Reliable Service** Only prestressed concrete tanks have a continuous steel diaphragm embedded in the wall to provide positive assurance of watertightness. The entire tank is wrapped top-to-bottom in multiple layers of high-strength wire, placing the tank in permanent compression and eliminating tension cracks.

BUILDING A NATGUN THERMAL STORAGE TANK

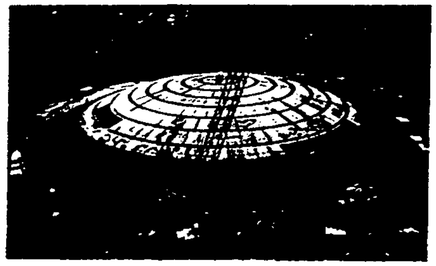
1 After excavation, Natgun places casting beds around the perimeter. Wall and dome panels are poured simultaneously with the tank floor, speeding construction.



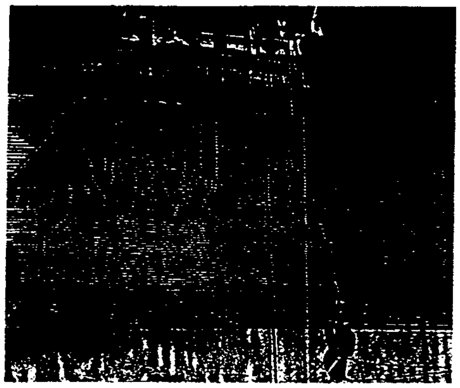
2 Panels are cast in "stacks" with a waterproof steel diaphragm (which becomes an integral part of each panel) serving as the bottom of the form. Expensive form work is minimized, and optimum quality achieved with ground level construction.



3 Wall panels are erected after the floor is completed. Panel joints are sealed water-tight using steel plates and high-strength mortar.



4 Dome panels are erected on shoring. The circumferential and radial joints are then cast in place.



5 After encasing the tank's steel diaphragm in shotcrete, Natgun places the tank in permanent compression by wrapping it with high-strength wire stressed to 140,000 psi, eliminating the potential for tension cracks. Each layer of prestressing is individually encased in shotcrete.

6 Once the prestressing wire has been encased, Natgun applies an additional layer of shotcrete to provide further corrosion protection. The tank is now complete and ready to be put in service.

After evaluation of a system's thermal energy needs by a plant or consulting engineer, Natgun Corporation provides complete design and construction services for the thermal storage tank.

No matter what your needs in a thermal storage tank, we have the expertise and experience to see your job through — not just to completion, but years down the line — providing durable, reliable, cost-saving service for generations to come.

Natgun has over five decades of experience designing and building precast, prestressed concrete water storage tanks. In that time, we have contributed numerous technical advances to prestressed concrete tank construction. Today, thousands of prestressed concrete tanks — some very old, and some brand new — are providing safe, reliable, cost-effective water storage to communities and industries across America.

NATGUN

PRECAST
PRESTRESSED
PREFERRED

Eleven Teal Road
Wakefield, Massachusetts 01880-1292
8111 Preston Road, Suite 701
Dallas, Texas 75225-6307
Or call 1-800-662-8486

Printed in U.S.A. 2/91 NatlGraph 5M

5.0 ENERGY CONSERVATION OPPORTUNITY: CHILLER HEAT RECOVERY FOR DOMESTIC HOT WATER

The Energy Engineering Analysis Program (EEAP) performed at Lyster Army Community Hospital in 1989 identified an Energy Conservation Opportunity (ECO 12) to utilize waste heat from one centrifugal chiller to preheat domestic hot water. The original ECO 12 is included as Appendix 5A of this ECO section. The objective of this analysis is to reevaluate the technical and economic feasibility of recovering heat from the chillers under present circumstances since this ECO has not been implemented. Additionally, consideration is given to the performance of this ECO based on the implementation of the previously described Cooling Storage ECO.

5.1 Existing Conditions

Domestic hot water is provided to the hospital from one 1,200 gallon storage tank in the main mechanical room. The water is heated by base steam and maintained at a temperature of 134°F for delivery to meet hospital requirements. The water in the tank is heated by an insertion type steam heater rated at 700 pounds of steam per hour.

5.2 Reevaluation Of Proposed Modifications

The recommended ECO proposes to add a 60 ton auxiliary condenser to one 230 ton centrifugal chiller, making it the primary chiller. The auxiliary condenser would then be utilized to preheat domestic hot water improving chiller performance by lowering head pressure and reducing the steam required to heat water. The analysis procedures to establish energy reductions in the original ECO have been reviewed and determined to be reasonable and are used in this new analysis. The implementation costs and energy cost savings are revised to be representative of current prices.

Installation cost based on the enclosed estimate has been increased from $21,870 to $27,820.

COST ESTIMATE ANALYSIS

For use of this form, see TM 5-800-2; the proponent agency is USACE.

INVITATION/CONTRACTOR	
EFFECTIVE PRICING DATE	
DATE PREPARED	3/20/93
PROJECT	AUXILARY CONDENSER
CODE (Check one)	☐ A ☐ B ☐ C ☐ OTHER
DRAWING NO.	
SHEET	1 OF 1 SHEETS
LOCATION	FT. RUCKER - LYSTER ARMY HOSP.
ESTIMATOR	
CHECKED BY	

TASK DESCRIPTION	QUANTITY: NO. OF UNITS	QUANTITY: UNIT MEAS	LABOR: MH UNIT	LABOR: TOTAL HRS	LABOR: UNIT PRICE	LABOR: COST	EQUIPMENT: UNIT PRICE	EQUIPMENT: COST	MATERIAL: UNIT PRICE	MATERIAL: COST	TOTAL	SHIPPING: UNIT WT	SHIPPING: TOTAL WT
60 TON AUX.													
CONDENSER													
INSTALLED BY													
TRANE	1					8500				6700			
PUMP	1					80				950			
CONTROL VALVE	1					100				1500			
REGULATING VALVE	1					50				220			
PIPE, VALVES, FTGS	LOT					1000				1500			
INSULATION						200				600			
						9930				11470	21400		
OH, TAXES &													
PROFIT @ 30%											6420		
TOTAL EST. COST											$27,820		
SOURCE: TRANE CO. & 1993 MEANS COST DATA													
TOTAL THIS SHEET													

DA FORM 5418-R, Apr 85

Natural gas costs have been reduced from $0.411/therm to $0.289/therm reducing projected savings from $3,960 to $2,785.

Electricity cost has been reduced from $0.043993/KWH to $0.0215/KWH reducing projected savings from $1,799 to $879.

The revised total projected savings are $3,664.

5.3 Revised ECIP Documentation For Original ECO Project And DD Form 1391

Since this project has an estimated cost less than $300,000, it must be grouped with other projects to qualify for the Energy Conservation Investment Program (ECIP). The project Life Cycle Cost Analysis indicates the following:

Annual Energy Savings:		
Electric	-	139.56 MBTU/Year
Natural Gas	-	963.60 MBTU/Year
Total	-	1,103.16 MBTU/Year
Annual Cost Savings:		
Electric	-	$879
Natural Gas	-	$2,785
Total	-	$3,664
Total Investment	-	$31,019
Simple Payback	-	8.47
Total Net Discounted Savings	-	$70,248
Savings To Investment Ratio (SIR)	-	2.26
Adjusted Internal Rate Of Return (AIRR)	-	8.00%

LIFE CYCLE COST ANALYSIS SUMMARY
ENERGY CONSERVATION INVESTMENT PROGRAM (ECIP)

LOCATION: Ft. Rucker REGION NO. 3 PROJECT NO. 2392
PROJECT TITLE: Limited Energy Studies FISCAL YEAR 1993
DISCRETE PORTION NAME: Chiller Heat Recovery For Domestic Hot Water
ANALYSIS DATE: 3/24/93 ECONOMIC LIFE 20 PREPARER Jackins

1. INVESTMENT COSTS:

A.	CONSTRUCTION COST	$ 27,820		
B.	SIOH	$ 1,530		
C.	DESIGN COST	$ 1,669		
D.	TOTAL COST (1A+1B+1C)	$ 31,019		
E.	SALVAGE VALUE OF EXISTING EQUIPMENT		$ 0	
F.	PUBLIC UTILITY COMPANY REBATE		$ 0	
G.	TOTAL INVESTMENT (1D-1E-1F)			$ 31,019

2. ENERGY SAVINGS (+)/COST(-):
DATE OF NISTIR 85-3273-X USED FOR DISCOUNT FACTORS Oct 1992

ENERGY SOURCE	COST $/MBTU(1)	SAVING MBTU/YR(2)	ANNUAL $ SAVINGS(3)	DISCOUNT FACTOR(4)	DISCOUNTED SAVINGS(5)
A. ELEC	$ 6.30	139.56	$ 879	14.65	$ 12,877
B. DIST	$		$		$
C. RESID	$		$		$
D. NG	$ 2.89	963.60	$ 2,785	20.60	$ 57,371
E. PPG	$		$		$
F. COAL	$		$		$
G. SOLAR	$		$		$
H. GEOTH	$		$		$
I. BIOMA	$		$		$
J. REFUS	$		$		$
K. WIND	$		$		$
L. OTHER	$		$		$
M. DEMAND SAVINGS			$		$
N. TOTAL		1,103.16	$ 3,664		$ 70,248

3. NON ENERGY SAVINGS (+) OR COST (-):

A. ANNUAL RECURRING (+/-)	$		
(1) DISCOUNT FACTOR (TABLE A)			
(2) DISCOUNTED SAVINGS/COST (3A X 3A1)			$

B. NON RECURRING SAVINGS (+) OR COST (-)

ITEM	SAVINGS(+) COST(-)(1)	YEAR OF OCCUR. (2)	DISCOUNT FACTOR(3)	DISCOUNTED SAVINGS(+)COST(-)(4)
a.	$			$
b.	$			$
c.	$			$
d. TOTAL	$			$

C. TOTAL NON ENERGY DISCOUNTED SAVINGS (3A2+3Bd4) $

4. SIMPLE PAYBACK 1G/(2N3+3A+(3Bd1/ECONOMIC LIFE)): 8.47 YEARS
5. TOTAL NET DISCOUNTED SAVINGS (2N5+3C): $70,248
6. SAVINGS TO INVESTMENT RATIO (SIR) 5/1G: 2.26
7. ADJUSTED INTERNAL RATE OF RETURN (AIRR): 8.00 %

1. COMPONENT	FY 19 93 MILITARY CONSTRUCTION PROJECT DATA	2. DATE
ARMY		25 March 93

3. INSTALLATION AND LOCATION	4. PROJECT TITLE
Lyster Army Community Hospital Fort Rucker, Alabama	ECIP

5. PROGRAM ELEMENT	6. CATEGORY CODE	7. PROJECT NUMBER	8. PROJECT COST ($000)
	80000		31

9. COST ESTIMATES

ITEM	U/M	QUANTITY	UNIT COST	COST ($000)
60 ton Auxiliary Condenser	LS	--	--	15
Pump	EA	1	1,030	1
Control Valve	EA	1	1,600	2
Regulating Valve	EA	1	270	0
Pipe, Valves, Fittings	LS	--	--	2
Insulation	LS	--	--	1
Miscellaneous Taxes	LS	--	--	6
Supervision, Inspection & Overhead (5.5%)				2
Design (6.0%)				2
TOTAL				31

10. DESCRIPTION OF PROPOSED CONSTRUCTION

The primary facility of the chiller heat recovery for domestic hot water system will include an auxiliary condenser, pump, control and regulating valve, pipes, valves, fittings and insulation. The work is new construction at Lyster Army Community Hospital. The purpose of this facility is to utilize waste heat from one of the existing chillers to preheat domestic hot water. Demolition of existing buildings is not required for site clearance. Accessibility for the handicapped is not required for functional reasons.

11. Project:

Install a chiller heat recovery system for preheating domestic hot water. This project will save $879 and 139.56 MBTU per year in electrical charges, and $2,785 and 963.60 MBTU per year in natural gas charges.

1. COMPONENT		2. DATE
ARMY	FY 19 93 MILITARY CONSTRUCTION PROJECT DATA	25 March 93

3. INSTALLATION AND LOCATION	
Lyster Army Community Hospital Fort Rucker, Alabama	
4. PROJECT TITLE	**5. PROJECT NUMBER**
ECIP	

REQUIREMENT:

This project is required to provide a reduction of overall natural gas and electrical costs by utilizing an auxiliary condenser on one of the chillers to preheat domestic hot water. The project has a Savings To Investment Ratio (SIR) of 2.26. The ECIP Life Cycle Cost Analysis summary sheet is attached.

CURRENT SITUATION:

Domestic hot water is currently provided to Lyster Army Community Hospital from a storage tank in the main mechanical room and is heated by Ft. Rucker's Base steam system which uses natural gas as its energy source. The auxiliary condenser would improve chiller performance by lowering head pressure and thereby lower electrical energy use. Natural gas usage would be reduced by using the waste heat from the chiller to heat domestic hot water instead of the Base steam system.

IMPACT:

Fort Rucker will continue to heat domestic hot water at Lyster Army Community Hospital by the basewide steam system and lose a potential annual savings of $3,664 in electrical and natural gas consumption costs.

5.4 ECO Analysis With Cooling Storage

The cooling storage strategy proposed in this study is based on avoiding all chiller operation during peak load hours for as much as eight months of the year. This would correspond to the same period as there would be peak domestic hot water usage. Since the heat recovered from the auxiliary condenser cannot be stored - water can only be preheated as use occurs - the cooling storage strategy will significantly reduce the potential for heat recovery with this ECO.

The original analysis of the heat recovery ECO was based on 915,253 ton-hours of chiller operation to determine both the electric and natural gas savings. If we assume that we eliminate the 230 ton chiller operation for 6 hours a day for eight months, we reduce the available ton-hours by up to (6 hrs X 30 days X 8 months X 230 tons) 331,200 ton-hours or 36%. This would reduce the total potential energy savings by the same amount to $2,345 increasing the simple payback to 11.85 years.

Chiller heat recovery for domestic hot water is not feasible if the Cooling Storage project is implemented.

SECTION 5.0 APPENDIX

CHILLER HEAT RECOVERY FOR DOMESTIC HOT WATER

LYSTER ARMY COMMUNITY HOSPITAL

APPENDIX 5A

ORIGINAL ECO FROM 1989 STUDY

CHILLER AUXILIARY CONDENSER

ECO 12 CHILLER AUXILIARY CONDENSER

LYSTER ARMY HOSPITAL

Existing Conditions: The centrifugal chilled water system consists of three centrifugal chillers: two 230 ton chillers and one 360 ton chiller. When in operation, each chiller produces waste heat due to the refrigeration cycle. The chillers are presently manually staged by operating personnel to meet buildings cooling load. Cooling is required year round.

Recommended Modifications: Add a 60 ton auxiliary condenser to one 230 ton chiller, making it the primary chiller. This auxiliary condenser can then be used for domestic hot water (DHW) preheat by connecting to the DHW system. Since DHW flow will not be adequate to operate the auxiliary condenser, a circulating pump will be required. A sketch of recommended modifications follows. All DHW will be preheated to 95°F when the chiller is in operation. This will reduce the steam required at the hospital, resulting in natural gas savings. When an auxiliary condenser is added, electrical energy consumption is also decreased due to increased condenser heat transfer surface area and a lower pressure differential required by the compressor.

Economic Summary:

Implementation Cost: $21,870

Energy Savings

Electric	139.56 MBTU/YR	$1,799
Nat Gas	963.60 MBTU/YR	$3,960
Total	1,103.16 MBTU/YR	$5,759

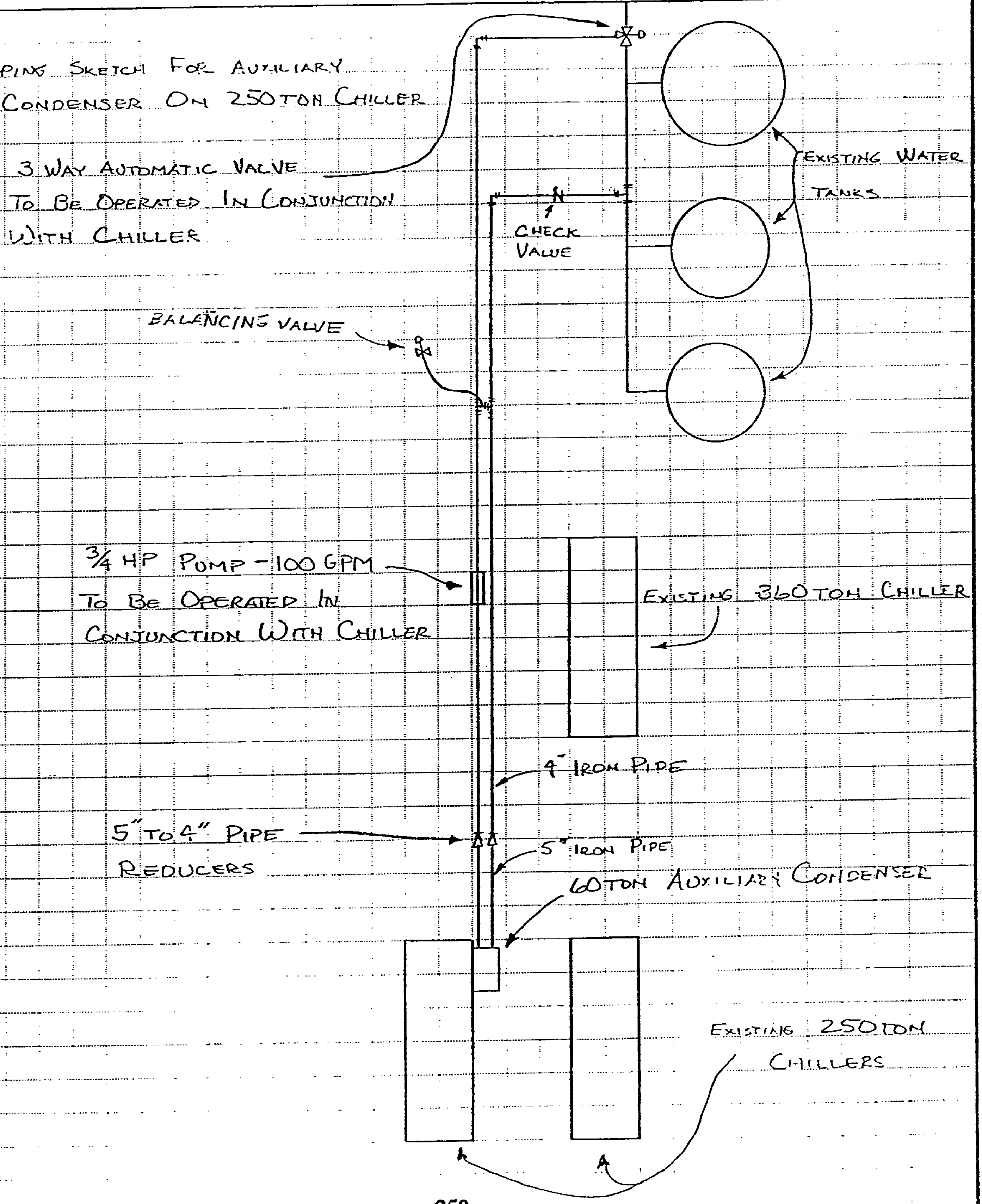
Simple Payback 3.8 years

SIR 3.86

ENERGY MANAGEMENT CONSULTANTS, INC.
P.O. Box 360687
BIRMINGHAM, AL 35236
(205) 985-9090

JOB Lyster Army Hospital - Auxiliary Chiller Condenser
SHEET NO 1 OF 1
CALCULATED BY MJB DATE 10/28/05
CHECKED BY ______ DATE ______
SCALE None

Piping Sketch For Auxiliary Condenser On 250 Ton Chiller



LIFE CYCLE COST ANALYSIS SUMMARY
ENERGY CONSERVATION INVESTMENT PROGRAM (ECIP)

LOCATION: FORT RUCKER REGION NO.: 4 PROJECT NUMBER: S-458
PROJECT TITLE: ENERGY SURVEY FISCAL YEAR: 1990
DISCRETE PORTION NAME: CHILLER AUXILIARY CONDENSER C:\CMW\RECO12.LCC
ANALYSIS DATE: 1-26-89 ECONOMIC LIFE: 20 PREPARED BY: MJB

1. INVESTMENT		
A. CONSTRUCTION COST	$21,793.27	
B. SIOH (1A * 5.5%)	$1,198.63	
C. DESIGN COST(1A * 6%)	$1,307.60	
D. ENERGY CREDIT CALC (1A+1B+1C) * 90%	$21,869.54	
E. SALVAGE VALUE	$0.00	
F. TOTAL INVESTMENT (1D-1E)		$21,869.54

2. ENERGY SAVINGS (+) / COST (-)
BASE YEAR ANNUAL SAVINGS, UNIT COST & DISCOUNTED SAVINGS

	FUEL	UNIT COST $/MBTU(1)	SAVINGS MBTU/YR(2)	ANNUAL $ SAVINGS(3)	DISCOUNT FACTOR(4)	DISCOUNTED SAVINGS(5)
A.	ELEC	$12.89	139.56	$1,798.99	9.99	$17,971.86
B.	DIST	$0.00	0.00	$0.00	14.21	$0.00
C.	RESI	$0.00	0.00	$0.00	14.39	$0.00
D.	NG.	$4.11	963.60	$3,960.40	16.76	$66,376.24
E.	COAL	$0.00	0.00	$0.00	12.09	$0.00
F.	TOTAL		1,103.16	$5,759.38		$84,348.09

3. NON ENERGY SAVINGS (+) / COST (-)			
A. ANNUAL RECURRING (+/-)		$0.00	
(1). DISCOUNT FACTOR (TABLE A)	10.59		
(2). DISTILLATE HANDLING COST (.0603*2B)		$0.00	
(3). DISCOUNTED SAVINGS/COST ((3A*3A2)*3A1)		$0.00	
B. NON RECURRING SAVINGS/COST NONE			
C. TOTAL NON ENERGY DISCOUNTED SAVINGS (+) COST (-) (3A3+3B)			$0.00
D. NON ENERGY DISCOUNTED SAVINGS IS = OR < 25% OF TOTAL			
4. FIRST YEAR DOLLAR SAVINGS (2F3+3A+(3B/ECONOMIC LIFE))		$5,759.38	
5. TOTAL NET DISCOUNTED DOLLAR SAVINGS (2F5+3C)			$84,348.09
6. DISCOUNT SAVINGS RATIO (IF < 1 PROJECT DOES NOT QUALIFY) (SIR) = (5/1F)		3.86	

ELECTRICAL ENERGY SAVINGS ASSOCIATED WITH INSTALLATION OF AUXILIARY CHILLER CONDENSER

Calculation For Estimated Electrical Energy Savings

Since chiller energy consumption varies with cooling loads, hours at a specific cooling load have been taken from TRACE. Only one 230 ton chiller will be fitted with an auxiliary condenser and instead of staggering chiller operation between the three chillers present, the 230 ton chiller with auxiliary condenser will be the primary chiller and the other chillers will be brought on line when cooling loads increase past capacity of the primary chiller. Electrical energy required for a 3/4 hp circulating pump must also be taken into consideration.

COOLING LOAD TONS	ANNUAL HOURS AT LOAD	TON-HOURS
32.39	3,387	109,704.93
64.77	1,323	85,690.71
97.16	869	84,432.04
129.55	664	86,021.20
161.94	153	24,776.82
194.32	187	36,337.84
230.00	2,123	488,290.00
	ANNUAL TON-HOURS	915,253.54

Without an auxiliary condenser, chiller energy consumption is 0.6700 KW/Ton. With an auxiliary condenser, chiller energy consumption is 0.6200 KW/Ton.

ANNUAL ELECTRICAL ENERGY CONSUMPTON

With automatic tube cleaners and no auxiliary condenser

0.6700 KW/Ton * 915,253.54 Ton-Hours = 613,220 KWH

With automatic tube cleaners and auxiliary condenser and 3/4 hp circulating pump

(0.6200 KW/Ton * 915,253.54 Ton-Hours)+(0.75 hp * 0.746 KW/hp * 8,706 Hours) = 572,328 KWH

ELECTRICAL ENERGY SAVINGS ASSOCIATED WITH INSTALLATION OF AUXILIARY CHILLER CONDENSER

ANNUAL ELECTRICAL ENERGY SAVINGS

613,220 KWH - 572,328 KWH = 40,892 KWH

ANNUAL DOLLAR SAVINGS

40,892 KWH * $0.043993/KWH = $1,799

X .0215 = ₱ 879

February 1989

ENERGY MANAGEMENT CONSULTANTS, INC.
P.O. Box 360687
BIRMINGHAM, AL 35236
(205) 985-9090

JOB Lyster Army Hospital - Fort Rucker
SHEET NO 1 OF 2
CALCULATED BY MJB DATE 11/7/93
CHECKED BY ______ DATE ______
SCALE ______

NATURAL GAS SAVINGS ASSOCIATED WITH INSTALLATION OF AUXILIARY CHILLER CONDENSER

CALCULATION FOR NATURAL GAS SAVINGS

ASSUME 424,860 GALLONS PER MONTH DOMESTIC HOT WATER CONSUMPTION. THIS AMOUNT IS DERIVED FROM THE TRACE RUN BASE NATURAL GAS CONSUMPTION WITH BOILER EFFICIENCY OF 80.8%. ALL DOMESTIC HOT WATER WILL BE PREHEATED TO 85°F FROM 65°F. SINCE THE CHILLER DOES NOT OPERATE, THESE CALCULATIONS WILL ASSUME AN OPERATING TIME OF 11 MONTHS PER YEAR.

CURRENT NATURAL GAS CONSUMPTION

$$\frac{424{,}860 \ {}^{GAL}/_{MONTH} \times 12 \ {}^{MONTHS}/_{YEAR} \times 8.33 \ {}^{POUNDS}/_{GAL} \times 1 \ {}^{BTU}/_{POUND\text{-}°F} \times (115°F - 65°F)}{100{,}000 \ {}^{BTU}/_{THERM} \times 80.8\%}$$

$$= 26{,}280 \ {}^{THERMS}/_{YEAR}$$

NATURAL GAS CONSUMPTION AFTER INSTALLATION OF AUXILIARY CONDENSER

$$\left(\frac{424{,}860 \ {}^{GAL}/_{MONTH} \times 11 \ {}^{MONTH}/_{YEAR} \times 8.33 \ {}^{POUNDS}/_{GAL} \times 1 \ {}^{BTU}/_{POUND\text{-}°F} \times (115°F - 85°F)}{100{,}000 \ {}^{BTU}/_{THERM} \times 80.8\%}\right)$$

$$+ \left(\frac{424{,}860 \ {}^{GAL}/_{MONTH} \times 1 \ {}^{MONTH}/_{YEAR} \times 8.33 \ {}^{POUNDS}/_{GAL} \times 1 \ {}^{BTU}/_{POUND\text{-}°F} \times (115°F - 65°F)}{100{,}000 \ {}^{BTU}/_{THERM} \times 80.8\%}\right)$$

$$= 16{,}644 \ {}^{THERMS}/_{YEAR}$$

ANNUAL NATURAL GAS SAVINGS

$$26{,}280 \ {}^{THERMS}/_{YEAR} - 16{,}644 \ {}^{THERMS}/_{YEAR} = 9{,}636 \ {}^{THERMS}/_{YEAR}$$

ENERGY
MANAGEMENT CONSULTANTS, INC.
P.O. Box 360687
BIRMINGHAM, AL 35236
(205) 985-9090

JOB Lyster Army Hospital - Fort Rucker

SHEET NO 2 OF 2

CALCULATED BY MJB DATE 11/7/88

CHECKED BY DATE

SCALE

NATURAL GAS SAVINGS ASSOCIATED WITH
INSTALLATION OF AUXILIARY CHILLER CONDENSER

ANNUAL DOLLAR SAVINGS

9,636 THERMS/YEAR × $0.411 /THERM = $3960

.289 = $2785

COST ESTIMATE ANALYSIS For use of this form, see TM 5-800-2; the proponent agency is USACE.	INVITATION/CONTRACTOR	EFFECTIVE PRICING DATE	DATE PREPARED
PROJECT Auxiliary Condenser For One 250 Ton Chiller	CODE (Check one) ☐ A ☐ B ☐ C ☐ OTHER	DRAWING NO.	SHEET 1 OF 2 SHEETS
LOCATION Fort Rucker - Lyster Army Hospital		ESTIMATOR	CHECKED BY

TASK DESCRIPTION	QUANTITY		LABOR				EQUIPMENT		MATERIAL		TOTAL	SHIPPING	
	NO. OF UNITS	UNIT MEAS	MH UNIT	TOTAL HRS	UNIT PRICE	COST	UNIT PRICE	COST	UNIT PRICE	COST		UNIT WT	TOTAL WT
60 Ton Auxiliary Condenser													
For CVHE-025 Unit													
Installed By TRANE													
Excluding Controls													
And Piping	1	Unit				7,625 ~~6,000~~				6,175			
3/4 HP Water Circulating													
Pump - 100 GPM	1	EA	4	4	10.62	42.48			880	880			
4" 3 Way Automatic													
Valve	1	EA	7	7	10.62	74.34			1,330	1,330			
4" Regulator Valve	1	EA.	2	2	10.62	21.24			165	165			
Pipe Reducer 5" To 4"	2	EA	1.	2	10.62	21.24			12	24			
4" Check Valve	1	EA	6	6	10.62	63.72			135	135			
4" Pipe Tee Fitting	3	EA	2	6	10.62	63.72			16.40	98.40			
4" ... Elbow Fitting	8	EA	1.5	12	10.62	127.44			10.05	80.40			
4" Iron Pipe Including	80	L.F.	.05	40	10.62	424.80			6.60	528			
Couplings And Hangers TOTAL THIS SHEET						6838.98				9415.80			

DA FORM 5418-R, Apr 85

COST ESTIMATE ANALYSIS
For use of this form, see TM 5-800-2; the proponent agency is USACE.

INVITATION/CONTRACTOR

EFFECTIVE PRICING DATE

DATE PREPARED

PROJECT: AUXILIARY CONDENSER FOR ONE 230 TON CHILLER

CODE (Check one) ☐ A ☐ B ☐ C ☐ OTHER

DRAWING NO.

SHEET 2 OF 2 SHEETS

LOCATION: FORT RUCKER – LYSTER ARMY HOSPITAL

ESTIMATOR

CHECKED BY

TASK DESCRIPTION	QUANTITY		LABOR				EQUIPMENT		MATERIAL		TOTAL	SHIPPING	
	NO. OF UNITS	UNIT MEAS	MH UNIT	TOTAL HRS	UNIT PRICE	COST	UNIT PRICE	COST	UNIT PRICE	COST		UNIT WT	TOTAL WT
PIPE INSULATION WITH													
COVER – 4 L.F. ADDED													
FOR EACH FITTING,													
VALVE AND FLANGE	144	L.F.	0.114	16.4	10.62	174.17			3.05	439.20			
SUB-TOTAL						7013.15				9,855			
LABOR BURDEN (18%)						1262.37							
OVERHEAD (16%)										1576.80			
PROFIT (10%)										985.50			
SALES TAX (5.5%)										542.03			
SUB-TOTAL						8575.52				12,959.33	21,534.85		
BOND (1.2%)				+	1.15	9862					258.42		
TOTAL											21,793.27		
SOURCES: TRANE – BIRMINGHAM													
1988 MEANS MECHANICAL COST DATA													
TOTAL THIS SHEET													

DA FORM 5418-R, Apr 85

TRANE

Birmingham Sales District
Commercial Systems Group
The Trane Company

620 S. Ninth Street
Birmingham AL 35233
205 251 2421

Jack M. Ballard, Jr.
District Manager

October 19, 1988

Energy Management Consultants
P.O. Box 360687
Birmingham, Al 35236

Attn: Mark Barnett

Re: Auxiliary Condensers for
Trane model CVHE

Mark,

Please find below a price for installing auxiliary condensers on Trane model CVHE units. This price does not include any water piping run to the condenser nor any controls.

Nominal 60 ton unit: $12,175.00 + # 13,800.00
Nominal 100 ton unit: $13,110.00

Please advise if we could be of any further service.

Yours very truly,

THE TRANE COMPANY

Scott

Scott Bourgeois
Birmingham Sales District

ESB/lkb

APPENDIX A

LIMITED ENERGY STUDIES

SCOPE OF WORK

CESAM-EN-CC

February 1992

SCOPE OF WORK

FOR

FY92 LIMITED ENERGY STUDIES

AT

FORT RUCKER, ALABAMA

Performed as part of the

ENERGY ENGINEERING ANALYSIS PROGRAM (EEAP)

APPENDIX "A"

CONTRACT NO: DACA01-92-C-0119

SCOPE OF WORK
FOR
FY92 LIMITED ENERGY STUDIES
FORT RUCKER, ALABAMA

TABLE OF CONTENTS

ANNEXES

1. <u>BRIEF DESCRIPTION OF WORK</u>: The Architect-Engineer (AE) shall:

1.1 Review the previously completed energy studies which apply to the buildings, systems, or energy conservation opportunities (ECOs) covered by this study.

1.2 Perform a limited site survey of specific buildings or areas to collect all data required to evaluate the specific ECOs included in this study.

1.3 Reevaluate the specific project or ECO from the previous study to determine its economic feasibility based on revised criteria, current site conditions and technical applicability.

1.4 Evaluate specific ECOs to determine their energy savings potential and economic feasibility.

1.5 Provide project documentation for recommended ECOs as detailed herein.

1.6 Prepare a comprehensive report to document all work performed, the results and all recommendations.

2. <u>GENERAL</u>

2.1 This study is limited to the evaluation of the specific buildings, systems, or ECOs listed in Annex A, DETAILED SCOPE OF WORK.

2.2 The information and analysis outlined herein are considered to be minimum requirements for adequate performance of this study.

2.3 For the buildings, systems or ECOs listed in Annex A, all methods of energy conservation which are reasonable and practical shall be considered, including improvements of operational methods and procedures as well as the physical facilities. All energy conservation opportunities which produce energy or dollar savings shall be documented in this report. Any energy conservation opportunity considered infeasible shall also be documented in the report with reasons for elimination.

2.4 The study shall consider the use of all energy sources applicable to each building, system, or ECO.

2.5 The "Energy Conservation Investment Program (ECIP) Guidance", described in letter from CEHSC-FU, dated 28 June 1991 and the latest revision from CEHSC-FU establishes criteria for ECIP projects and shall be used for performing the economic analyses of <u>all</u> ECOs and projects. The program, Life Cycle Cost In Design (LCCID), has been developed for performing life cycle cost calculations in accordance with ECIP guidelines and is referenced in the ECIP Guidance. If any program other than LCCID is proposed for life cycle cost analysis, it must use the mode of calculation specified in the ECIP Guidance, the output must be in the format

of the ECIP LCCA summary sheet, and it must be submitted for approval to the Contracting Officer.

2.6 Computer modeling will be used to determine the energy savings of ECOs which would replace or significantly change an existing heating, ventilating, and air-conditioning (HVAC) system. The requirement to use computer modeling applies only to heated and air-conditioned or air-conditioned-only buildings which exceed 8,000 square feet or heated-only buildings in excess of 20,000 square feet. Modeling will be done using a professionally recognized and proven computer program or programs that integrate architectural features with air-conditioning, heating, lighting and other energy-producing or consuming systems. These programs will be capable of simulating the features, systems, and thermal loads of the building under study. The program will use established weather data files and may perform calculations on a true hour-by-hour basis or may condense the weather files and the number of calculations into several "typical" days per month. The Detailed Scope of Work, Annex A, will list programs that are acceptable to the Contracting Officer. If the AE desires to use a different program, it must be submitted for approval with a sample run, an explanation of all input and output data, and a summary of program methodology and energy evaluation capabilities.

2.7 Energy conservation opportunities determined to be technically and economically feasible shall be developed into projects acceptable to installation personnel. This may involve combining similar ECOs into larger packages which will qualify for ECIP, MCA, or PCIP funding, and determining in coordination with installation personnel the appropriate packaging and implementation approach for all feasible ECOs.

2.7.1 Projects which qualify for ECIP funding shall be identified, separately listed, and prioritized by the Savings to Investment Ratio (SIR).

2.7.2 All feasible non-ECIP projects shall be ranked in order of highest to lowest SIR.

3. PROJECT MANAGEMENT

3.1 Project Managers. The AE shall designate a project manager to serve as a point of contact and liaison for work required under this contract. Upon award of this contract, the individual shall be immediately designated in writing. The AE's designated project manager shall be approved by the Contracting Officer prior to commencement of work. This designated individual shall be responsible for coordination of work required under this contract. The Contracting Officer will designate a project manager to serve as the Government's point of contact and liaison for all work required under this contract. This individual will be the Government's representative.

3.2 Installation Assistance. The Commanding Officer or authorized representative at the installation will designate an individual to assist the AE in obtaining information and establishing contacts necessary to accomplish the work required under this contract. This individual will be the installation representative.

3.3 Public Disclosures. The AE shall make no public announcements or disclosures relative to information contained or developed in this contract, except as authorized by the Contracting Officer.

3.4 Meetings. Meetings will be scheduled whenever requested by the AE or the Contracting Officer for the resolution of questions or problems encountered in the performance of the work. The AE's project manager and the Government's representative shall be required to attend and participate in all meetings pertinent to the work required under this contract as directed by the Contracting Officer. These meetings, if necessary, are in addition to the presentation and review conferences.

3.5 Site Visits, Inspections, and Investigations. The AE shall visit and inspect/investigate the site of the project as necessary and required during the preparation and accomplishment of the work.

3.6 Records

3.6.1 The AE shall provide a record of all significant conferences, meetings, discussions, verbal directions, telephone conversations, etc., with Government representative(s) relative to this contract in which the AE and/or designated representative(s) thereof participated. These records shall be dated and shall identify the contract number, and modification number if applicable, participating personnel, subject discussed and conclusions reached. The AE shall forward to the Contracting Officer within ten calendar days, a reproducible copy of the records.

3.6.2 The AE shall provide a record of requests for and/or receipt of Government-furnished material, data, documents, information, etc., which if not furnished in a timely manner, would significantly impair the normal progression of the work under this contract. The records shall be dated and shall identify the contract number and modification number, if applicable. The AE shall forward to the Contracting Officer within ten calendar days, a reproducible copy of the record of request or receipt of material.

3.7 Interviews. The AE and the Government's representative shall conduct entry and exit interviews with the Director of Engineering and Housing before starting work at the installation and after completion of the field work. The Goverment's representative shall schedule the interviews at least one week in advance.

3.7.1 Entry. The entry interview shall describe the intended procedures for the survey and shall be conducted prior to commencing work at the facility. As a minimum, the interview shall cover the following points:

a. Schedules.

b. Names of energy analysts who will be conducting the site survey.

c. Proposed working hours.

d. Support requirements from the Director of Engineering and Housing.

3.7.2 Exit. The exit interview shall briefly describe the items surveyed and probable areas of energy conservation. The interview shall also solicit input and advice from the Director of Engineering and Housing.

4. SERVICES AND MATERIALS. All services, materials (except those specifically enumerated to be furnished by the Government), equipment, labor, supervision and travel necessary to perform the work and render the data required under this contract are included in the lump sum price of the contract.

5. PROJECT DOCUMENTATION. All energy conservation opportunities which the AE has considered shall be included in one of the following categories and presented in the report as such:

5.1 ECIP Projects. To qualify as an ECIP project, an ECO, or several ECOs which have been combined, must have a construction cost estimate greater than $300,000, a Savings to Investment Ratio greater than one and a simple payback period of less than eight years. The overall project and each discrete part of the project shall have an SIR greater than one. All projects meeting the above criteria shall be arranged as specified in paragraph 2.7.1 and shall be provided with programming documentation. Programming documentation shall consist of a DD Form 1391, life cycle cost analysis (LCCA) summary sheet(s) (with necessary backup data to verify the numbers presented), and a Project Development Brochure (PDB). A life cycle cost analysis summary sheet shall be developed for each ECO and for the overall project when one or more ECOs are combined. The energy savings for projects consisting of multiple ECOs must take into account the synergistic effects of the individual ECOs.

5.2 Non-ECIP Projects. Projects which do not meet ECIP criteria with regard to cost estimate, payback period, or non-energy (75%) qualification test, but which have an SIR greater than one shall be documented. Projects or ECOs in this category shall be arranged as specified in paragraph 2.7.2 and shall be provided with the following documentation: the life cycle cost analysis (LCCA) summary sheet completely filled out, a description of the work to be accomplished, backup data for the LCCA, ie, energy

savings calculations and cost estimate(s), and the simple payback period. The energy savings for projects consisting of multiple ECOs must take into account the synergistic effects of the individual ECOs. In addition these projects shall have the necessary documentation prepared, as required by the Government's representative, for one of the following categories:

a. Quick Return on Investment Program (QRIP). This program is for projects which have a total cost greater than $3,000 but less than $100,000 and a simple payback period of two years or less.

b. Productivity Enhancing Capital Investment Program (PECIP). This program is for projects which have a total cost of greater than $3,000 but less than $100,000 and a simple payback period of four years or less.

c. OSD Productivity Investment Funding (OSD PIF). This program is for projects which have a total cost of more than $100,000 and a simple payback period of four years or less.

The above programs and the required documentation forms are all described in detail in AR 5-4, Change No. 1.

d. Regular Military Construction Army (MCA) Program. This program is for projects which have a total cost greater than $300,000 and a simple payback period of eight to twenty-five years. Documentation shall consist of DD Form 1391 and a Project Development Brochure.

e. Low Cost/No Cost Projects. These are projects which the Director of Engineering and Housing (DEH) can perform using his resources. Documentation shall be as required by the DEH.

5.3 Nonfeasible ECOs. All ECOs which the AE has considered but which are not feasible, shall be documented in the report with reasons and justifications showing why they were rejected.

6. DETAILED SCOPE OF WORK. The Detailed Scope of Work is contained in Annex A.

7. WORK TO BE ACCOMPLISHED.

7.1 Review Previous Studies. Review the previous studies which apply to the specific building, system, or ECO covered by this study. This review should acquaint the AE with the work that has been performed previously. Much of the information the AE may need to develop the ECOs in this study may be contained in the previous studies.

7.2 Perform a Limited Site Survey. The AE shall obtain all necessary data to evaluate the ECOs or projects by conducting a site survey. However, the AE is encouraged to use any data that may have been documented in a previous study. The AE shall document his site survey on forms developed for the survey, or on

standard forms, and submit these completed forms as part of the report. All test and/or measurement equipment shall be properly calibrated prior to its use.

7.3 Reevaluate Selected Projects. The AE shall reevaluate the projects listed in Annex A. These projects were previously identified but have not been accomplished. If a project is acceptable as is, that is, there are no changes to the basic project, the energy savings shown in the previous study may be accepted as accurate but the energy cost and construction cost estimates shall be updated based on the most current data available. With the above information the project shall then be analyzed based on current ECIP criteria. If the original project evaluation is suspected of being inaccurate, but the project or ECO is still considered feasible, the AE shall develop the project from the beginning and analyze it with the current ECIP guidance. This project shall be separately listed in the report.

7.4 Evaluate Selected ECOs. The AE shall analyze the ECOs listed in Annex A. These ECOs shall be analyzed in detail to determine their feasibility. Savings to Investment Ratios (SIRs) shall be determined using current ECIP guidance. The AE shall provide all data and calculations needed to support the recommended ECO. All assumptions and engineering equations shall be clearly stated. Calculations shall be prepared showing how all numbers in the ECO were figured. Calculations shall be an orderly step-by-step progression from the first assumption to the final number. Descriptions of the products, manufacturers catalog cuts, pertinent drawings and sketches shall also be included. A life cycle cost analysis summary sheet shall be prepared for each ECO and included as part of the supporting data.

7.5 Combine ECOs Into Recommended Projects. During the Interim Review Conference, as outlined in paragraph 7.6.1, the AE will be advised of the DEH's preferred packaging of recommended ECOs into projects for implementation. Some projects may be a combination of several ECOs, and others may contain only one. These projects will be evaluated and arranged as outlined in paragraphs 5.1, 5.2, and 5.3. Energy savings calculations shall take into account the synergistic effects of multiple ECOs within a project and the effects of one project upon another. The results of this effort will be reported in the Final Submittal per par 7.6.2.

7.6 Submittals, Presentations and Reviews. The work accomplished shall be fully documented by a comprehensive report. The report shall have a table of contents and shall be indexed. Tabs and dividers shall clearly and distinctly divide sections, subsections, and appendices. All pages shall be numbered. Names of the persons primarily responsible for the project shall be included. The AE shall give a formal presentation of the interim submittal to installation, command, and other Government personnel. Slides or view graphs showing the results of the study to date shall be used during the presentation. During the presentation, the personnel in attendance shall be given ample opportunity to ask questions and discuss any changes deemed necessary to the study.

A review conference will be conducted the same day, following the presentation. Each comment presented at the review conference will be discussed and resolved or action items assigned. It is anticipated that the presentation and review conference will require approximately one working day. The presentation and review conference will be at the installation on the date agreeable to the Director of Engineering and Housing, the AE and the Government's representative. The Contracting Officer may require a resubmittal of any document(s), if such document(s) are not approved because they are determined by the Contracting Officer to be inadequate for the intended purpose.

7.6.1 Interim Submittal. An interim report shall be submitted for review after the field survey has been completed and an analysis has been performed on all of the ECOs. The report shall indicate the work which has been accomplished to date, illustrate the methods and justifications of the approaches taken and contain a plan of the work remaining to complete the study. Calculations showing energy and dollar savings, SIR, and simple payback period of all the ECOs shall be included. The results of the ECO analyses shall be summarized by lists as follows:

a.All ECOs eliminated from consideration shall be grouped into one listing with reasons for their elimination as discussed in par 5.3.

b.All ECOs which were analyzed shall be grouped into two listings, recommended and non-recommended, each arranged in order of descending SIR. These lists may be subdivided by building or area as appropriate for the study. The AE shall submit the Scope of Work and any modifications to the Scope of Work as an appendix to the report. A narrative summary describing the work and results to date shall be a part of this submittal. At the Interim Submittal and Review Conference, the Government's and AE's representatives shall coordinate with the Director of Engineering and Housing to provide the AE with direction for packaging or combining ECOs for programming purposes and also indicate the fiscal year for which the programming or implementation documentation shall be prepared. The survey forms completed during this audit shall be submitted with this report. The survey forms only may be submitted in final form with this submittal. They should be clearly marked at the time of submission that they are to be retained. They shall be bound in a standard three-ring binder which will allow repeated disassembly and reassembly of the material contained within.

7.6.2 Final Submittal. The AE shall prepare and submit the final report when all sections of the report are 100% complete and all comments from the interim submittal have been resolved. The AE shall submit the Scope of Work for the study and any modifications to the Scope of Work as an appendix to the submittal. The report shall contain a narrative summary of conclusions and recommendations, together with all raw and supporting data, methods used, and sources of information. The report shall integrate all aspects of the study. The recommended projects, as determined in

accordance with paragraph 5, shall be presented in order of priority by SIR. The lists of ECOs specified in paragraph 7.6.1 shall also be included for continuity. The final report and all appendices shall be bound in standard three-ring binders which will allow repeated disassembly and reassembly. The final report shall be arranged to include:

a. An Executive Summary to give a brief overview of what was accomplished and the results of this study using graphs, tables and charts as much as possible (See Annex B for minimum requirements).

b. The narrative report describing the problem to be studied, the approach to be used, and the results of this study.

c. Documentation for the recommended projects (includes LCCA Summary Sheets).

d. Appendices to include as a minimum:

1) Energy cost development and backup data

2) Detailed calculations

3) Cost estimates

4) Computer printouts (where applicable)

5) Scope of Work

ANNEX A

DETAILED SCOPE OF WORK

FY92 LIMITED ENERGY STUDIES, FORT RUCKER, ALABAMA

1. All of the facilities to be studied in this contract are located at Fort Rucker, Alabama.

2. The AE shall provide all necessary effort, services, and materials required to accomplish the work specified.

3. The installation representative for this contract will be Mr. William DeJournett, Energy Manager, Directorate of Engineering and Housing.

4. Completion and Payment Schedule: The following schedule shall be used as a guide in approving payments on this contract. The final report for this study shall be due not later than 270 days after Notice to Proceed.

MILESTONE	PERCENT OF CONTRACT AMOUNT AUTHORIZED FOR PAYMENT
Entry Interview	10
Completion of Field Work	25 - 10/15/92
Receipt of Interim Submittal	75 - 11/15/92
Completion of Interim Presentation & Review	85 - 12/15/92
Receipt of Final Report	100 - 12/31/92

5. Work To Be Accomplished: There are two main areas of work in this contract, an LP gas storage study, and evaluation of two energy conservation opportunities (ECOs) for Lyster Army Hospital.

a. LP Gas Storage: Evaluate the technical and economic feasibility of building and operating a liquified petroleum gas (LPG) storage facility. The primary heating fuel at Fort Rucker is natural gas; it is used in central steam plants and in central forced-air furnaces for family housing. Natural gas is purchased from the Southeast Alabama Gas District at their lowest rate. However, Fort Rucker also pays a natural gas demand charge based on the amount of natural gas used during curtailment. During a curtailment period, the natural gas demand is reduced as much as possible by switching the central steam plants to oil; but the family housing area cotinues to use natural gas. An LPG storage system would provide the capability of injecting a mixture of air and propane into the natural gas disribution system during curtailment to reduce natural gas demand. This would result in lower gas bills throughout the year.

b. Lyster Army Hospital: An EEAP study was completed for Lyster Army Hospital in 1989. The final report of this study will be provided to the AE. The following two ECOs should be evaluated separately and in combination.

1) Cooling Storage System for Peak Demand Reduction: Evaluate the technical and economic feasibility of reducing peak electrical demand at the hospital by use of a cooling storage system. The AE will determine the optimum type of cooling storage system for the hospital. For accurate evaluation of this ECO, building thermal loads must be modeled. In the 1989 EEAP study, the building was modeled using Trane TRACE. TRACE will be an acceptable program to use for modeling. If the AE wants to obtain and reuse the TRACE input from the 1989 study, such plan will first be submitted to the Contracting Officer for approval. Other acceptable programs are listed in paragraph 6.

2) Chiller Heat Recovery for Domestic Hot Water: Evaluate the technical and economic feasibility of recovering heat from the hospital chillers for preheating domestic hot water with and without the cooling storage system mentioned above. Heat recovery from chillers was recommended in the 1989 study but has not been implemented.

6. The simulation programs acceptable for use in this study are listed below. Any substitutes must be submitted and approved as outlined in the basic scope of work.

a. Building Loads and System Thermodynamics (BLAST)

b. DOE 2.1B

c. Carrier E20 or Hourly Analysis Program (HAP)

d. Trane Air-Conditioning Economics (TRACE)

7. Government-Furnished Information: The following documents will be furnished to the AE:

a. ENERGY SURVEY, LYSTER ARMY COMMUNITY HOSPITAL, FORT RUCKER, ALABAMA; February 1989, Energy Management Consultants, Inc, Birmingham, AL.

b. ETL 1110-3-282, Energy Conservation

c. Energy Conservation Investment Program (ECIP) Guidance, dated 28 June 1991 and the latest revision with current energy prices and discount factors for life cycle cost analysis.

d. TM 5-785, Engineering Weather Data (applcable portions)

e. TM 5-800-2, Cost Estimates, Military Construction.

f. AR 5-4, Change No. 1, Department of the Army Productivity Improvement Program.

g. AR 415-15, 1 Jan 84, Military Construction, Army (MCA) Program Development

h. The latest MCP Index.

8. A computer program titled Life Cycle Costing in Design (LCCID) is available from the BLAST Support Office in Urbana, Illinois for a nominal fee. This computer program can be used for performing the economic calculations for ECIP and non-ECIP ECOs. The AE is encouraged to obtain and use this computer program. The BLAST Support Office can be contacted at 144 Mechanical Engineering Building, 1206 West Green Street, Urbana, Illinois 61801. The telephone number is (217) 333-3977 or (800) 842-5278.

9. Direct Distribution of Submittals: The AE shall make direct distribution of correspondence, minutes, report submittals, and responses to comments as indicated by the following schedule:

AGENCY	CORRESPONDENCE	EXECUTIVE SUMMARIES	REPORTS	FIELD NOTES
Commander US Army Aviation Center and Fort Rucker ATTN: ATZQ-DEH-U (DeJournett) Fort Rucker, AL 36362	-	3	3	1*
Commander US Army Training and Doctrine Command ATTN: ATEN-FE (Mr Capra) Fort Monroe, VA, 23651	-	1	1	-
Commander US Army Corps of Engineers ATTN: CEMP-ET (Mr Gentil) 20 Massachusetts Avenue NW Washington, DC, 20314 - 1000	-	1	1	-
Commander USAED, South Atlantic ATTN: CESAD-EN-TE (Mr Baggette) 77 Forsyth Street, SW Atlanta, GA 30335 - 6801	-	1	1	-
Commander USAED, Mobile ATTN: CESAM-EN-CC (Battaglia) PO Box 2288; Mobile, AL 36628	2	2	2	1*
Commander US Army Logistics Evaluation Agency ATTN: LOEA-PL (Mr Keath) New Cumberland Army Depot New Cumberland, PA, 17070 - 5007	-	1	1	-

* Field Notes submitted in final form at interim submittal.

ANNEX B

EXECUTIVE SUMMARY GUIDELINE

1. Introduction.

2. Building Data (types, number of similar buildings, sizes, etc.)

3. Present Energy Consumption of Buildings or Systems Studied.

   o Total Annual Energy Used.

   o Source Energy Consumption.

   Electricity - KWH, Dollars, BTU
   Fuel Oil - GALS, Dollars, BTU
   Natural Gas - THERMS, Dollars, BTU
   Propane - GALS, Dollars, BTU
   Other - QTY, Dollars, BTU

4. Reevaluated Projects Results.

5. Energy Conservation Analysis.

   o ECOs Investigated.

   o ECOs Recommended.

   o ECOs Rejected. (Provide economics or reasons)

   o ECIP Projects Developed. (Provide list)*

   o Non-ECIP Projects Developed. (Provide list)*

   o Operational or Policy Change Recommendations.

   * Include the following data from the life cycle cost analysis summary sheet: the cost (construction plus SIOH), the annual energy savings (type and amount), the annual dollar savings, the SIR, the simple payback period and the analysis date.

6. Energy and Cost Savings.

   o Total Potential Energy and Cost Savings.

   o Percentage of Energy Conserved.

   o Energy Use and Cost Before and After the Energy Conservation Opportunities are Implemented.

ANNEX C

REQUIRED DD FORM 1391 DATA

To facilitate ECIP project approval, the following supplemental data shall be provided:

a. In title block clearly identify projects as "ECIP."

b. Complete description of each item of work to be accomplished including quantity, square footage, etc.

c. A comprehensive list of buildings, zones, or areas including building numbers, square foot floor area, designated temporary or permanent, and usage (administration, patient treatment, etc.).

d. List references, and assumptions, and provide calculations to support dollar and energy savings, and indicate any added costs.

(1) If a specific building, zone, or area is used for sample calculations, identify building, zone or area, category, orientation, square footage, floor area, window and wall area for each exposure.

(2) Identify weather data source.

(3) Identify infiltration assumptions before and after improvements.

(4) Include source of expertise and demonstrate savings claimed. Identify any special or critical environmental conditions such as pressure relationships, exhaust or outside air quantities, temperatures, humidity, etc.

e. Claims for boiler efficiency improvements must identify data to support present properly adjusted boiler operation and future expected efficiency. If full replacement of boilers is indicated, explain rejection of alternatives such as replace burners, nonfunctioning controls, etc. Assessment of the complete existing installation is required to make accurate determinations of required retrofit actions.

f. Lighting retrofit projects must identify number and type of fixtures, and wattage of each fixture being deleted and installed. New lighting shall be only of the level to meet current criteria. Lamp changes in existing fixtures is not considered an ECIP type project.

g. An ECIP life cycle cost analysis summary sheet as shown in the ECIP Guidance shall be provided for the complete project and for each discrete part included in the project. The SIR is applicable to all segments of the project. Supporting documentation consisting of basic engineering and economic calculations showing how savings were determined shall be included.

h. The DD Form 1391 face sheet shall include, for the complete project, the annual dollar and MBTU savings, SIR, simple amortization period and a statement attesting that all buildings and retrofit actions will be in active use throughout the amortization period.

i. The calendar year in which the cost was calculated shall be clearly shown on the DD Form 1391.

j. For each temporary building included in a project, separate documentation is required showing (1) a minimum 10-year continuing need, based on the installation's annual real property utilization survey, for active building retention after retrofit, (2) the specific retrofit action applicable and (3) an economic analysis supporting the specific retrofit.

k. Nonappropriated funded facilities will not be included in an ECIP project without an accompanying statement certifying that utility costs are not reimbursable.

l. Any requirements required by ECIP guidance dated 25 April 1988 and any revisions thereto. Note that unescalated costs/savings are to be used in the economic analyses.

m. The five digit category number for all ECIP projects except for Family Housing is 80000. The category code number for Family Housing projects is 71100.

APPENDIX B

LIMITED ENERGY STUDIES

TRANE TRACE BUILDING BASELINE MODEL

INPUT AND OUTPUT

01 Card - Job Information

Project: LYSTER ARMY COMMUNITY HOSPITAL
Location: FORT RUCKER, ALABAMA
Client: U.S. ARMY CORPS OF ENGINEERS
Program User: ENGINEERING RESOURCE GROUP, INC.
Comments: LIMITED ENERGY STUDIES

-----CARD 08-- Climatic Information -----

Weather Code	Summer Clearness Number	Winter Clearness Number	Summer Design Dry Bulb	Summer Design Wet Bulb	Winter Design Dry Bulb	Building Orientation	Summer Ground Reflect	Winter Ground Reflect
MOBILE	.9	.9	94	80	24			

-----CARD 09-- Load Simulation Periods-----

1st Month Cooling Simulation	Last Month Cooling Simulation	Peak Cooling Load Hr	1st Month Summer Period	Last Month Summer Period	1st Month Daylight Savings	Last Month Daylight Savings
					APR	OCT

-----CARD 10 -- Load Simulation Parameters-----

Cooling Load Method	Heating Load Method	Ventilation Method	Airflow Input Units	Airflow Output Units	Room Circulation Rate	Put Wall RA Load to Room
TETD-TA1	UATD					YES

-----CARD 11-- Energy Simulation Parameters-----

1st Month Energy Simulation	Last Month Energy Simulation	Level Of Calculation	Holiday Code	Calendar Code	Building Floor Area
		ZONE			

-------------------- Load Section Alternative #1 --------------------

---- Load Alternative ----

Number	Description
1	BASELINE MODEL

-----CARD 20-- General Room Parameters ----------

Room Number	Zone Reference Number	Room Descrip	Floor Length	Floor Width	Const Type	Plenum Height	Acoustic Ceiling Resistance	Floor to Floor Height	Duplicate Floors Multiplier	Duplicate Rooms per Zone	Perimeter Depth
1	1	SURGERY1	441	1		0		11			
2	2	SUR CORR	927	1		0		11			
3	3	SURGERY2	400	1		0		11			
4	4	DEL 1	294	1		0		11			
5	5	DEL 2	273	1		0		11			
6	6	LABOR	1695	1		0		11			
7	7	SUR. LOUN	1968	1		0		11			
8	8	NURSERY	879	1		0		11			
9	9	OB RECOV	252	1		0		11			
10	10	OR RECOV	405	1		0		11			
11	11	PERIM N.	4644	1		0		11			
12	12	PERIM. S	1980	1		0		11			
13	13	INT. N	4968	1		0		11			
14	14	INT. S	5244	1		0		11			
15	15	ICU	756	1		0		11			
16	16	KIT ADMIN	1032	1		1		12			
17	17	FOOD PRE	1828	1		1		12			
18	18	XRAY EXT	5336	1		1		12			
19	19	XRAY INT	2352	1		1		12			
20	20	PHY THER	4404	1		1		12			
21	21	ADMIN	1790	1		1		12			
22	22	SUR.CLINIC	3116	1		1		12			
23	23	SUR.CLINIC	5822	1		1		12			
24	24	MECH	1072	1		1		12			
25	25	E.R.AC10	3915	1		1		12			
26	26	ADMIN	2964	1		1		12			
27	27	DENT EXT	1210	1		1		12			
28	28	DENT INT	5899	1		1		12			
29	29	EENT EXT	1512	1		1		12			
30	30	EENT INT	3696	1		1		12			
31	31	AREA S	3240	1		1		12			
32	32	DINING	1734	1		1		12			
33	33	AC8 NORT	1579	1		1		12			
34	34	AC8 EAST	2367	1		1		12			
35	35	AC7 SO	4967	1		1		12			
36	36	AC8 SO	2268	1		1		12			
37	37	AC7 WEST	1772	1		1		12			
38	38	AC7 INT	13657	1		1		12			
39	39	AC8 INT	15184	1		1		12			
40	40	AC9 LAB	8039	1		1		12			
41	41	WEST CMS	4776	1		1		12			
42	42	AC11 WES	3671	1		1		12			
43	43	AC14 WES	1763	1		1		12			
44	44	AC13 SOU	1798	1		1		12			
45	45	AC11 EAS	3067	1		1		12			
46	46	AC14 EAS	6380	1		1		12			
47	47	AC13 EAS	5310	1		1		12			

-----CARD 20-- General Room Parameters ---

Room Number	Zone Reference Number	Room Descrip	Floor Length	Floor Width	Const Type	Plenum Height	Acoustic Ceiling Resistance	Floor to Floor Height	Duplicate Floors Multiplier	Duplicate Rooms per Zone	Perimeter Depth
48	48	AC11 INT	4485	1		1		12			
49	49	AC14 INT	5828	1		1		12			
50	50	AC13 INT	7562	1		1		12			
51	51	AC17 WES	1119	1		1		12			
52	52	AC17 NOR	3295	1		1		12			
53	53	AC17 INT	9055	1		1		12			
54	54	AC16 INT	3278	1		1		12			
55	55	AC16 NOR	680	1		1		12			
56	56	AC16	8368	1		1		12			
57	57	AC18	1170	1		1		12			

-----CARD 21-- Thermostat Parameters ---

Room Number	Cooling Room Design DB	Room Design RH	Cooling T'stat Driftpoint	Cooling T'stat Schedule	Heating Room Design DB	Heating T'stat Driftpoint	Heating T'stat Schedule	T'stat Location Flag	Mass / No. Hrs Average	Carpet On Floor
1	72		72	THERM72	72	72	THERM72	ZONE		
2	72		72	THERM72	72	72	THERM72	ZONE		
3	72		72	THERM72	72	72	THERM72	ZONE		
4	72		72	THERM72	72	72	THERM72	ZONE		
5	72		72	THERM72	72	72	THERM72	ZONE		
6	72		72	THERM72	72	72	THERM72	ZONE		
7	72		72	THERM72	72	72	THERM72	ZONE		
8	72		72	THERM72	72	72	THERM72	ZONE		
9	72		72	THERM72	72	72	THERM72	ZONE		
10	72		72	THERM72	72	72	THERM72	ZONE		
11	72		72	THERM72	72	72	THERM72	ZONE		
12	72		72	THERM72	72	72	THERM72	ZONE		
13	72		72	THERM72	72	72	THERM72	ZONE		
14	72		72	THERM72	72	72	THERM72	ZONE		
15	72		72	THERM72	72	72	THERM72	ZONE		
16	72		72	THERM72	72	72	THERM72	ZONE		
17	72		72	THERM72	72	72	THERM72	ZONE		
18	72		72	THERM72	72	72	THERM72	ZONE		
19	72		72	THERM72	72	72	THERM72	ZONE		
20	72		72	THERM72	72	72	THERM72	ZONE		
21	72		72	THERM72	72	72	THERM72	ZONE		
22	72		72	THERM72	72	72	THERM72	ZONE		
23	72		72	THERM72	72	72	THERM72	ZONE		
24	72		72	THERM72	72	72	THERM72	ZONE		
25	72		72	THERM72	72	72	THERM72	ZONE		
26	72		72	THERM72	72	72	THERM72	ZONE		
27	72		72	THERM72	72	72	THERM72	ZONE		
28	72		72	THERM72	72	72	THERM72	ZONE		
29	72		72	THERM72	72	72	THERM72	ZONE		
30	72		72	THERM72	72	72	THERM72	ZONE		

-----CARD 21-- Thermostat Parameters -----

Room Number	Cooling Room Design DB	Room Design RH	Cooling T'stat Driftpoint	Cooling T'stat Schedule	Heating Room Design DB	Heating T'stat Driftpoint	Heating T'stat Schedule	T'stat Location Flag	Mass / No. Hrs Average	Carpet On Floor
31	72		72	THERM72	72	72	THERM72	ZONE		
32	72		72	THERM72	72	72	THERM72	ZONE		
33	72		72	THERM72	72	72	THERM72	ZONE		
34	72		72	THERM72	72	72	THERM72	ZONE		
35	72		72	THERM72	72	72	THERM72	ZONE		
36	72		72	THERM72	72	72	THERM72	ZONE		
37	72		72	THERM72	72	72	THERM72	ZONE		
38	72		72	THERM72	72	72	THERM72	ZONE		
39	72		72	THERM72	72	72	THERM72	ZONE		
40	72		72	THERM72	72	72	THERM72	ZONE		
41	72		72	THERM72	72	72	THERM72	ZONE		
42	72		72	THERM72	72	72	THERM72	ZONE		
43	72		72	THERM72	72	72	THERM72	ZONE		
44	72		72	THERM72	72	72	THERM72	ZONE		
45	72		72	THERM72	72	72	THERM72	ZONE		
46	72		72	THERM72	72	72	THERM72	ZONE		
47	72		72	THERM72	72	72	THERM72	ZONE		
48	72		72	THERM72	72	72	THERM72	ZONE		
49	72		72	THERM72	72	72	THERM72	ZONE		
50	72		72	THERM72	72	72	THERM72	ZONE		
51	72		72	THERM72	72	72	THERM72	ZONE		
52	72		72	THERM72	72	72	THERM72	ZONE		
53	72		72	THERM72	72	72	THERM72	ZONE		
54	72		72	THERM72	72	72	THERM72	ZONE		
55	72		72	THERM72	72	72	THERM72	ZONE		
56	72		72	THERM72	72	72	THERM72	ZONE		
57	72		72	THERM72	72	72	THERM72	ZONE		

-----CARD 22-- Roof Parameters -----

Room Number	Roof Number	Roof Equal to Floor?	Roof Length	Roof Width	Roof U-Value	Const Type	Roof Direction	Roof Tilt	Roof Alpha
1	1	YES			.1	48			
2	1	YES			.1	48			
3	1	YES			.1	48			
4	1	YES			.1	48			
5	1	YES			.1	48			
6	1	YES			.25	48			
7	1	YES			.1	48			
8	1	YES			.1	48			
9	1	YES			.1	48			
10	1	YES			.1	48			
11	1	YES			.1	48			
12	1	YES			.1	48			
13	1	YES			.1	48			

-----CARD 22-- Roof Parameters ---

Room Number	Roof Number	Roof Equal to Floor?	Roof Length	Roof Width	Roof U-Value	Const Type	Roof Direction	Roof Tilt	Roof Alpha
14	1	YES			.1	48			
15	1	YES			.1	48			
19	1	YES			.05	48			
23	1	YES			.05	48			
24	1		500	1	.05	48			
25	1	YES			.05	48			
27	1		605	1	.05	48			
29	1	YES			.05	48			
30	1	YES			.05	48			
31	1	YES			.05	48			
33	1	YES			.15	23			
34	1	YES			.15	23			
35	1	YES			.15	23			
36	1	YES			.15	23			
37	1	YES			.15	23			
38	1	YES			.15	23			
39	1	YES			.15	23			
40	1	YES			.15	23			
41	1	YES			.15	23			
42	1	YES			.15	23			
43	1	YES			.15	23			
44	1	YES			.15	23			
45	1	YES			.15	23			
46	1	YES			.15	23			
47	1	YES			.15	23			
48	1	YES			.15	23			
49	1	YES			.15	23			
50	1	YES			.15	23			
51	1	YES			.15	23			
52	1	YES			.15	23			
53	1	YES			.15	23			
57	1	YES			.15	23			

-----CARD 24-- Wall Parameters ---

Room Number	Wall Number	Wall Length	Wall Height	Wall U-Value	Wall Constuc Type	Wall Direction	Wall Tilt	Wall Alpha	Ground Reflectance Multiplier
1	1	546	1	.25	59	293			
2	1	273	1	.25	59	293			
4	1	455	1	.25	59	203			
5	1	169	1	.25	59	113			
7	1	520	1	.1	59	293			
9	1	156	1	.25	59	113			
11	1	2288	1	.25	59	23			
12	1	1196	1	.25	59	203			

-----CARD 24-- Wall Parameters ---

Room Number	Wall Number	Wall Length	Wall Height	Wall U-Value	Wall Constuc Type	Wall Direction	Wall Tilt	Wall Alpha	Ground Reflectance Multiplier
15	1	468	1	.25	59	23			
17	1	130	1	.15	59	23			
19	1	1274	1	.15	59	293			
25	1	592	1	.25	59	293			
27	1	1157	1	.25	59	113			
29	1	1092	1	.15	59	113			
32	1	663	1	.25	59	23			
33	1	962	1	.15	58	23			
34	1	2420	1	.15	58	113			
35	1	1417	1	.15	58	203			
36	1	2119	1	.15	58	203			
37	1	2093	1	.15	58	293			
40	1	494	1	.15	58	113			
41	1	910	1	.15	58	293			
42	1	910	1	.15	58	293			
43	1	1222	1	.15	58	293			
44	1	1079	1	.15	58	203			
45	1	910	1	.15	58	113			
46	1	936	1	.15	58	113			
47	1	1976	1	.15	58	113			
51	1	481	1	.15	58	293			
52	1	2041	1	.15	58	23			
55	1	520	1	.15	58	23			
57	1	600	1	.15	58	293			

-----CARD 25-- Wall/Glass Parameters ---

Room Number	Wall Number	Glass Length	Glass Width	Pct Glass or No. of Windows	Glass U-Value	Shading Coefficient	External Shading Type	Internal Shading Type	Percent Solar to Ret. Air	Visible Transmittance	Inside Visible Reflectance
11	1			17	1.13	1		3		.9	
12	1			5	1.13	1		3		.9	
15	1			17	1.13	1		3		.9	
25	1			20	1.13	1		3		.9	
27	1			10	1.17	1		3		.9	
32	1			55	1.17	1		3		.9	
33	1			11	.49	.58		4		.5	
34	1			8	.49	.58		4		.5	
35	1			18	.49	.58		4		.5	
36	1			12	.49	.58		4		.5	
37	1			10	.49	.58		4		.5	
42	1			5	.49	.58		4		.5	
43	1			5	.49	.58		4		.5	
44	1			8	.49	.58		4		.5	
45	1			10	.49	.58		4		.5	
46	1			10	.49	.58		4		.5	

-----CARD 25-- Wall/Glass Parameters -----

Room Number	Wall Number	Glass Length	Glass Width	Pct Glass or No. of Windows	Glass U-Value	Shading Coefficient	External Shading Type	Internal Shading Type	Percent Solar to Ret. Air	Visible Transmittance	Inside Visible Reflectance
51	1			5	.49	.58		4		.5	
52	1			5	.49	.58		4		.5	

-----CARD 26-- Schedules -----

Room Number	People	Lights	Ventilation	Infiltration	Reheat Minimum	Cooling Fans	Heating Fan	Auxiliary Fan	Room Exhaust	Daylighting Controls
1	PEOP10	LITE10			AVAIL	AVAIL				
2	PEOP10	LITE10			AVAIL	AVAIL				
3	PEOP10	LITE10			AVAIL	AVAIL				
4	PEOP10	LITE10			AVAIL	AVAIL				
5	PEOP10	LITE10			AVAIL	AVAIL				
6	PEOP10	LITE10			AVAIL	AVAIL				
7	PEOP10	LITE10			AVAIL	AVAIL				
8	PEOP10	LITE10			AVAIL	AVAIL				
9	PEOP10	LITE10			AVAIL	AVAIL				
10	PEOP10	LITE10			AVAIL	AVAIL				
11	PEOP15	LITE15			AVAIL	AVAIL		AVAIL		
12	PEOP15	LITE15			AVAIL	AVAIL		AVAIL		
13	PEOP15	LITE15			AVAIL	AVAIL				
14	PEOP15	LITE15			AVAIL	AVAIL				
15	PEOP15	LITE15			AVAIL	AVAIL		AVAIL		
16	PEOP26	LITE26				AVAIL				
17	PEOP26	LITE26				AVAIL				
18	PEOP26	LITE26				AVAIL				
19	PEOP26	LITE26				AVAIL				
20	PEOP26	LITE26				AVAIL				
21	PEOP26	LITE26				AVAIL				
22	PEOP26	LITE26				AVAIL				
23	PEOP26	LITE26				AVAIL				
24	PEOP26	LITE26				AVAIL				
25	PEOP26	LITE26				AVAIL				
26	PEOP26	LITE26				AVAIL				
27	PEOP57	LITE57				AVAIL				
28	PEOP57	LITE57				AVAIL				
29	PEOP57	LITE57				AVAIL				
30	PEOP57	LITE57				AVAIL				
31	PEOP57	LITE57				AVAIL				
32	PEOP57	LITE57				AVAIL				
33	PEOP57	LITE57				AVAIL				
34	PEOP57	LITE57				AVAIL				
35	PEOP57	LITE57				AVAIL				
36	PEOP57	LITE57				AVAIL				
37	PEOP57	LITE57				AVAIL				
38	PEOP57	LITE57				AVAIL				
39	PEOP57	LITE57				AVAIL				

-----CARD 26-- Schedules -----

Room Number	People	Lights	Ventilation	Infiltration	Reheat Minimum	Cooling Fans	Heating Fan	Auxiliary Fan	Room Exhaust	Daylighting Controls
40	PEOP57	LITE57				AVAIL				
41	PEOP57	LITE57				AVAIL				
42	PEOP57	LITE57				AVAIL				
43	PEOP57	LITE57				AVAIL				
44	PEOP57	LITE57				AVAIL				
45	PEOP57	LITE57				AVAIL				
46	PEOP57	LITE57				AVAIL				
47	PEOP57	LITE57				AVAIL				
48	PEOP57	LITE57				AVAIL				
49	PEOP57	LITE57				AVAIL				
50	PEOP57	LITE57				AVAIL				
51	PEOP57	LITE57				AVAIL				
52	PEOP57	LITE57				AVAIL				
53	PEOP57	LITE57				AVAIL				
54	PEOP57	LITE57				AVAIL				
55	PEOP57	LITE57				AVAIL				
56	PEOP57	LITE57				AVAIL				
57	PEOP57	LITE57				AVAIL				

-----CARD 27-- People and Lights -----

Room Number	People Value	People Units	People Sensible	People Latent	Lighting Value	Lighting Units	Lighting Fixture Type	Ballast Factor	Percent Lights to Ret. Air	--- Daylighting ---- Reference Point 1	Reference Point 2
1	75	SF-PERS	345	435	5.9	WATT-SF			0		
2	300	SF-PERS	345	435	1.0	WATT-SF			0		
3	75	SF-PERS	345	435	7.0	WATT-SF			0		
4	75	SF-PERS	345	435	8.2	WATT-SF			0		
5	75	SF-PERS	345	435	8.8	WATT-SF			0		
6	150	SF-PERS	345	435	1.5	WATT-SF			0		
7	300	SF-PERS	345	435	.94	WATT-SF			0		
8	150	SF-PERS	255	255	1.4	WATT-SF			0		
9	75	SF-PERS	255	325	1.4	WATT-SF			0		
10	100	SF-PERS	315	325	1.0	WATT-SF			0		
11	100	SF-PERS	230	190	1.1	WATT-SF			0		
12	100	SF-PERS	230	190	.92	WATT-SF			0		
13	300	SF-PERS	230	190	.47	WATT-SF			0		
14	300	SF-PERS	230	190	.47	WATT-SF			0		
15	150	SF-PERS	230	190	1.0	WATT-SF			0		
16	200	SF-PERS	255	255	1.22	WATT-SF			5		
17	500	SF-PERS	345	435	1.53	WATT-SF			5		
18	500	SF-PERS	315	325	1.25	WATT-SF			5		
19	400	SF-PERS	345	435	1.67	WATT-SF			5		
20	400	SF-PERS	315	325	1.12	WATT-SF			5		
21	100	SF-PERS	255	255	1.86	WATT-SF			5		
22	250	SF-PERS	255	255	1.44	WATT-SF			5		
23	200	SF-PERS	255	255	1.62	WATT-SF			5		

-----CARD 27-- People and Lights ----------

Room Number	People Value	People Units	People Sensible	People Latent	Lighting Value	Lighting Units	Lighting Fixture Type	Ballast Factor	Percent Lights to Ret. Air	--- Daylighting ---- Reference Point 1	Reference Point 2
24	1000	SF-PERS	345	435	.97	WATT-SF			5		
25	200	SF-PERS	345	435	1.39	WATT-SF			5		
26	300	SF-PERS	345	435	2.21	WATT-SF			5		
27	300	SF-PERS	345	435	2.19	WATT-SF			5		
28	300	SF-PERS	345	435	1.75	WATT-SF			5		
29	300	SF-PERS	345	435	1.39	WATT-SF			5		
30	300	SF-PERS	345	435	1.39	WATT-SF			5		
31	300	SF-PERS	345	435	1.45	WATT-SF			5		
32	50	SF-PERS	345	435	1.13	WATT-SF			5		
33	300	SF-PERS	345	435	2.08	WATT-SF			5		
34	300	SF-PERS	345	435	1.56	WATT-SF			5		
35	300	SF-PERS	345	435	1.25	WATT-SF			5		
36	300	SF-PERS	345	435	1.94	WATT-SF			5		
37	300	SF-PERS	345	435	1.82	WATT-SF			5		
38	200	SF-PERS	345	345	1.45	WATT-SF			5		
39	200	SF-PERS	345	435	1.15	WATT-SF			5		
40	200	SF-PERS	345	435	1.37	WATT-SF			5		
41	500	SF-PERS	345	435	1.24	WATT-SF			5		
42	500	SF-PERS	345	435	1.76	WATT-SF			5		
43	500	SF-PERS	345	435	1.59	WATT-SF			5		
44	500	SF-PERS	345	435	2.28	WATT-SF			5		
45	500	SF-PERS	345	435	.92	WATT-SF			5		
46	500	SF-PERS	345	435	1.71	WATT-SF			5		
47	500	SF-PERS	345	435	1.83	WATT-SF			5		
48	500	SF-PERS	345	435	1.00	WATT-SF			5		
49	500	SF-PERS	345	435	1.30	WATT-SF			5		
50	500	SF-PERS	345	435	1.55	WATT-SF			5		
51	500	SF-PERS	345	435	1.38	WATT-SF			5		
52	500	SF-PERS	345	435	2.04	WATT-SF			5		
53	500	SF-PERS	345	435	1.45	WATT-SF			5		
54	500	SF-PERS	345	435	1.34	WATT-SF			5		
55	500	SF-PERS	345	435	1.72	WATT-SF			5		
56	500	SF-PERS	345	435	.95	WATT-SF			5		
57	100	SF-PERS	345	435	1.79	WATT-SF			5		

-----CARD 28--- Miscellaneous Equipment ----------

Room Number	Misc Equipment Number	Equipment Descrip	Energy Consump Value	Energy Consump Units	Schedule Code	Energy Meter Code	Percent of Load Sensible	Percent Misc. Load to Room	Percent Misc. Sens to Ret. Air	Radiant Fraction	Optiona Air Pat
1	1	MISC EQ	1	BTUH-SF	MISC10	ELEC					SYS-EXH
2	1	MISC EQ	1	BTUH-SF	MISC10	ELEC					SYS-EXH
3	1	MISC EQ	1	BTUH-SF	MISC10	ELEC					SYS-EXH
4	1	MISC EQ	1	BTUH-SF	MISC10	ELEC					SYS-EXH
5	1	MISC EQ	1	BTUH-SF	MISC10	ELEC					SYS-EXH
6	1	MISC EQ	1	BTUH-SF	MISC10	ELEC					SYS-EXH

-----CARD 28--- Miscellaneous Equipment ---

Room Number	Misc Equipment Number	Equipment Descrip	Energy Consump Value	Energy Consump Units	Schedule Code	Energy Meter Code	Percent of Load Sensible	Percent Misc. Load to Room	Percent Misc. Sens to Ret. Air	Radiant Fraction	Optiona Air Pat
7	1	MISC EQ	1	BTUH-SF	MISC10	ELEC					SYS-EXE
8	1	MISC EQ	1	BTUH-SF	MISC10	ELEC					SYS-EXE
9	1	MISC EQ	1	BTUH-SF	MISC10	ELEC					SYS-EXE
10	1	MISC EQ	1	BTUH-SF	MISC10	ELEC					SYS-EXE
11	1	MISC EQ	.5	BTUH-SF	MISC15	ELEC					SYS-EXE
12	1	MISC EQ	.5	BTUH-SF	MISC15	ELEC					SYS-EXE
13	1	MISC EQ	.5	BTUH-SF	MISC15	ELEC					SYS-EXE
14	1	MISC EQ	.5	BTUH-SF	MISC15	ELEC					SYS-EXE
15	1	MISC EQ	.5	BTUH-SF	MISC15	ELEC					SYS-EXE
16	1	MISC EQ	.25	BTUH-SF	MISC26	ELEC					SYS-EXE
17	1	MISC EQ	1	BTUH-SF	MISC26	ELEC	50				SYS-EXE
18	1	MISC EQ	.5	BTUH-SF	MISC26	ELEC					SYS-EXE
19	1	MISC EQ	1.5	BTUH-SF	MISC26	ELEC					SYS-EXE
20	1	MISC EQ	.75	BTUH-SF	MISC26	ELEC	67				SYS-EXE
21	1	MISC EQ	.25	BTUH-SF	MISC26	ELEC					SYS-EXE
22	1	MISC EQ	.25	BTUH-SF	MISC26	ELEC					SYS-EXE
23	1	MISC EQ	.25	BTUH-SF	MISC26	ELEC					SYS-EXE
24	1	MISC EQ	.25	BTUH-SF	MISC26	ELEC					SYS-EXE
25	1	MISC EQ	.25	BTUH-SF	MISC26	ELEC					SYS-EXE
26	1	MISC EQ	.2	BTUH-SF	MISC26	ELEC					SYS-EXE
27	1	MISC EQ	.2	BTUH-SF	MISC57	ELEC					SYS-EXE
28	1	MISC EQ	.2	BTUH-SF	MISC57	ELEC					SYS-EXE
29	1	MISC EQ	.2	BTUH-SF	MISC57	ELEC					SYS-EXE
30	1	MISC EQ	.2	BTUH-SF	MISC57	ELEC					SYS-EXE
31	1	MISC EQ	.2	BTUH-SF	MISC57	ELEC					SYS-EXE
32	1	MISC EQ	.2	BTUH-SF	MISC57	ELEC					SYS-EXE
33	1	MISC EQ	.2	BTUH-SF	MISC57	ELEC					SYS-EXE
34	1	MISC EQ	.2	BTUH-SF	MISC57	ELEC					SYS-EXE
35	1	MISC EQ	.2	BTUH-SF	MISC57	ELEC					SYS-EXE
36	1	MISC EQ	.2	BTUH-SF	MISC57	ELEC					SYS-EXE
37	1	MISC EQ	.2	BTUH-SF	MISC57	ELEC					SYS-EXE
38	1	MISC EQ	.1	BTUH-SF	MISC57	ELEC					SYS-EXE
39	1	MISC EQ	.1	BTUH-SF	MISC57	ELEC					SYS-EXE
40	1	MISC EQ	.2	BTUH-SF	MISC57	ELEC					SYS-EXE
41	1	MISC EQ	1.2	BTUH-SF	MISC57	ELEC	83				SYS-EXE
42	1	MISC EQ	.25	BTUH-SF	MISC57	ELEC					SYS-EXE
43	1	MISC EQ	.25	BTUH-SF	MISC57	ELEC					SYS-EXE
44	1	MISC EQ	.25	BTUH-SF	MISC57	ELEC					SYS-EXE
45	1	MISC EQ	.25	BTUH-SF	MISC57	ELEC					SYS-EXE
46	1	MISC EQ	.25	BTUH-SF	MISC57	ELEC					SYS-EXE
47	1	MISC EQ	.25	BTUH-SF	MISC57	ELEC					SYS-EXE
48	1	MISC EQ	.25	BTUH-SF	MISC57	ELEC					SYS-EXE
49	1	MISC EQ	.25	BTUH-SF	MISC57	ELEC					SYS-EXE
50	1	MISC EQ	.25	BTUH-SF	MISC57	ELEC					SYS-EXE
51	1	MISC EQ	.2	BTUH-SF	MISC57	ELEC					SYS-EXE
52	1	MISC EQ	.2	BTUH-SF	MISC57	ELEC					SYS-EXE
53	1	MISC EQ	.2	BTUH-SF	MISC57	ELEC					SYS-EXE

-----CARD 28--- Miscellaneous Equipment

Room Number	Misc Equipment Number	Equipment Descrip	Energy Consump Value	Energy Consump Units	Schedule Code	Energy Meter Code	Percent of Load Sensible	Percent Misc. Load to Room	Percent Misc. Sens to Ret. Air	Radiant Fraction	Optiona Air Pat
54	1	MISC EQ	.2	BTUH-SF	MISC57	ELEC					SYS-EXE
55	1	MISC EQ	.2	BTUH-SF	MISC57	ELEC					SYS-EXE
56	1	MISC EQ	.2	BTUH-SF	MISC57	ELEC					SYS-EXE
57	1	MISC EQ	.2	BTUH-SF	MISC57	ELEC					SYS-EXE

-----CARD 29--- Room Airflows

	Ventilation				Infiltration				Reheat Minimum	
	Cooling		Heating		Cooling		Heating			
Room Number	Value	Units	Value	Units	Value	Units	Value	Units	Value	Units
1	100	PCT-MCLG	100	PCT-MCLG	.01	CFM-SF	.01	CFM-SF	1.50	CFM-SF
2	100	PCT-MCLG	100	PCT-MCLG	.01	CFM-SF	.01	CFM-SF	1.50	CFM-SF
3	100	PCT-MCLG	100	PCT-MCLG	.01	CFM-SF	.01	CFM-SF	1.50	CFM-SF
4	100	PCT-MCLG	100	PCT-MCLG	.01	CFM-SF	.01	CFM-SF	1.50	CFM-SF
5	100	PCT-MCLG	100	PCT-MCLG	.01	CFM-SF	.01	CFM-SF	1.50	CFM-SF
6	100	PCT-MCLG	100	PCT-MCLG	.01	CFM-SF	.01	CFM-SF	1.50	CFM-SF
7	100	PCT-MCLG	100	PCT-MCLG	.01	CFM-SF	.01	CFM-SF	1.50	CFM-SF
8	100	PCT-MCLG	100	PCT-MCLG	.01	CFM-SF	.01	CFM-SF	1.50	CFM-SF
9	100	PCT-MCLG	100	PCT-MCLG	.01	CFM-SF	.01	CFM-SF	1.50	CFM-SF
10	100	PCT-MCLG	100	PCT-MCLG	.01	CFM-SF	.01	CFM-SF	1.50	CFM-SF
11	100	PCT-MCLG	100	PCT-MCLG	.01	CFM-SF	.01	CFM-SF	.427	CFM-SF
12	100	PCT-MCLG	100	PCT-MCLG	.01	CFM-SF	.01	CFM-SF	.427	CFM-SF
13	100	PCT-MCLG	100	PCT-MCLG	.01	CFM-SF	.01	CFM-SF	.427	CFM-SF
14	100	PCT-MCLG	100	PCT-MCLG	.01	CFM-SF	.01	CFM-SF	.427	CFM-SF
15	100	PCT-MCLG	100	PCT-MCLG	.01	CFM-SF	.01	CFM-SF	.427	CFM-SF
16	172	CFM	172	CFM	.01	CFM-SF	.01	CFM-SF		
17	306	CFM	306	CFM	.01	CFM-SF	.01	CFM-SF		
18	892	CFM	892	CFM	.01	CFM-SF	.01	CFM-SF		
19	393	CFM	393	CFM	.01	CFM-SF	.01	CFM-SF		
20	736	CFM	736	CFM	.01	CFM-SF	.01	CFM-SF		
21	299	CFM	299	CFM	.01	CFM-SF	.01	CFM-SF		
22	520	CFM	520	CFM	.01	CFM-SF	.01	CFM-SF		
23	973	CFM	973	CFM	.01	CFM-SF	.01	CFM-SF		
24	179	CFM	179	CFM	.01	CFM-SF	.01	CFM-SF		
25	654	CFM	654	CFM	.01	CFM-SF	.01	CFM-SF		
26	638	CFM	638	CFM	.01	CFM-SF	.01	CFM-SF		
27	261	CFM	261	CFM	.01	CFM-SF	.01	CFM-SF		
28	1271	CFM	1271	CFM	.01	CFM-SF	.01	CFM-SF		
29	326	CFM	326	CFM	.01	CFM-SF	.01	CFM-SF		
30	796	CFM	796	CFM	.01	CFM-SF	.01	CFM-SF		
31	698	CFM	698	CFM	.01	CFM-SF	.01	CFM-SF		
32	374	CFM	374	CFM	.01	CFM-SF	.01	CFM-SF		
33	141	CFM	141	CFM	.01	CFM-SF	.01	CFM-SF		
34	211	CFM	211	CFM	.01	CFM-SF	.01	CFM-SF		
35	443	CFM	443	CFM	.01	CFM-SF	.01	CFM-SF		
36	202	CFM	202	CFM	.01	CFM-SF	.01	CFM-SF		

-----CARD 29--- Room Airflows -----

	Ventilation				Infiltration					
Room	Cooling		Heating		Cooling		Heating		Reheat Minimum	
Number	Value	Units	Value	Units	Value	Units	Value	Units	Value	Units
37	158	CFM	158	CFM	.01	CFM-SF	.01	CFM-SF		
38	1219	CFM	1219	CFM	.01	CFM-SF	.01	CFM-SF		
39	1355	CFM	1355	CFM	.01	CFM-SF	.01	CFM-SF		
40	6810	CFM	6810	CFM	.01	CFM-SF	.01	CFM-SF		
41	1090	CFM	1090	CFM	.01	CFM-SF	.01	CFM-SF		
42	838	CFM	838	CFM	.01	CFM-SF	.01	CFM-SF		
43	402	CFM	402	CFM	.01	CFM-SF	.01	CFM-SF		
44	410	CFM	410	CFM	.01	CFM-SF	.01	CFM-SF		
45	700	CFM	700	CFM	.01	CFM-SF	.01	CFM-SF		
46	1456	CFM	1456	CFM	.01	CFM-SF	.01	CFM-SF		
47	1212	CFM	1212	CFM	.01	CFM-SF	.01	CFM-SF		
48	1024	CFM	1024	CFM	.01	CFM-SF	.01	CFM-SF		
49	1330	CFM	1330	CFM	.01	CFM-SF	.01	CFM-SF		
50	1726	CFM	1726	CFM	.01	CFM-SF	.01	CFM-SF		
51	158	CFM	158	CFM	.01	CFM-SF	.01	CFM-SF		
52	465	CFM	465	CFM	.01	CFM-SF	.01	CFM-SF		
53	1279	CFM	1279	CFM	.01	CFM-SF	.01	CFM-SF		
54	463	CFM	463	CFM	.01	CFM-SF	.01	CFM-SF		
55	96	CFM	96	CFM	.01	CFM-SF	.01	CFM-SF		
56	1182	CFM	1182	CFM	.01	CFM-SF	.01	CFM-SF		
57	165	CFM	165	CFM	.01	CFM-SF	.01	CFM-SF		

-----CARD 30- Fan Airflows -----

	Main				Auxiliary					
Room	Cooling		Heating		Cooling		Heating		Room Exhaust	
Number	Value	Units	Value	Units	Value	Units	Value	Units	Value	Units
1	662	CFM	662	CFM						
2	1391	CFM	1391	CFM						
3	600	CFM	600	CFM						
4	531	CFM	531	CFM						
5	474	CFM	474	CFM						
6	2543	CFM	2543	CFM						
7	2952	CFM	2952	CFM						
8	1319	CFM	1319	CFM						
9	378	CFM	378	CFM						
10	608	CFM	608	CFM						
11	2994	CFM	2994	CFM	992	CFM	992	CFM		
12	1304	CFM	1304	CFM	381	CFM	381	CFM		
13	2121	CFM	2121	CFM						
14	2239	CFM	2239	CFM						
15	475	CFM	475	CFM	203	CFM	203	CFM		
16	434	CFM	434	CFM						
17	887	CFM	887	CFM						
18	2124	CFM	2124	CFM						
19	1640	CFM	1640	CFM						

-----CARD 30- Fan Airflows ---

Room	Main				Auxiliary					
	----Cooling----		----Heating----		----Cooling----		----Heating----		--Room Exhaust--	
Number	Value	Units	Value	Units	Value	Units	Value	Units	Value	Units
20	1664	CFM	1664	CFM						
21	1214	CFM	1214	CFM						
22	1421	CFM	1421	CFM						
23	3555	CFM	3555	CFM						
24	353	CFM	353	CFM						
25	3800	CFM	3800	CFM						
26	1939	CFM	1939	CFM						
27	2417	CFM	2417	CFM						
28	3182	CFM	3182	CFM						
29	1061	CFM	1061	CFM						
30	1996	CFM	1996	CFM						
31	1506	CFM	1506	CFM						
32	3406	CFM	3406	CFM						
33	1750	CFM	1750	CFM						
34	2787	CFM	2787	CFM						
35	5033	CFM	5033	CFM						
36	3273	CFM	3273	CFM						
37	2571	CFM	2571	CFM						
38	11929	CFM	11929	CFM						
39	12507	CFM	12507	CFM						
40	9026	CFM	9026	CFM						
41	4592	CFM	4592	CFM						
42	3884	CFM	3884	CFM						
43	2056	CFM	2056	CFM						
44	2409	CFM	2409	CFM						
45	2898	CFM	2898	CFM						
46	6608	CFM	6608	CFM						
47	2130	CFM	2130	CFM						
48	3802	CFM	3802	CFM						
49	5267	CFM	5267	CFM						
50	7187	CFM	7187	CFM						
51	1332	CFM	1332	CFM						
52	4370	CFM	4370	CFM						
53	9612	CFM	9612	CFM						
54	1130	CFM	1130	CFM						
55	298	CFM	298	CFM						
56	2187	CFM	2187	CFM						
57	1633	CFM	1633	CFM						

-----CARD 34-- Internal Shading ---

Shading Type	Overall U-Value	Overall Shading Coefficent	Schedule Code	Shade Location	Visible Transmittance	Lockouts: Min OADB	Max Solar	Solar Ctrl Prob	Max Glare	Glare Ctrl Prob
3	.81	.64	AVAIL	INSIDE	.21					
4	.43	.39	AVAIL	INSIDE	.12					

-------------------- System Section Alternative #1 --------------------

-----CARD 39-- System Alternative -----

Number	Description
1	BASELINE MODEL

-----CARD 40--- System Type ---

System Set Number	System Type	------------OPTIONAL VENTILATION SYSTEM------------ Ventil Deck Location	Cooling SADBVh	Heating SADBVh	Cooling Schedule	Heating Schedule	Fan Static Pressure
1	BPMZ						
2	TRH						
3	DD						
4	DD						
5	MZ						
6	MZ						
7	MZ						
8	MZ						

-----CARD 41-- Zone Assignment ---

System Set	Ref #1		Ref #2		Ref #3		Ref #4		Ref #5		Ref #6	
Number	Begin	End	Begin	End	Begin	End	Begin	End	Begin	End	Begin	End
1	1	10										
2	11	15										
3	16	25										
4	26	32										
5	33	39										
6	40	40										
7	41	50										
8	51	57										

-----CARD 42--- Fan SP and Duct Parameters---

System Set Number	Cool Fan SP	Heat Fan SP	Return Fan SP	Mn Exh Fan SP	Aux Fan SP	Rm Exh Fan SP	Cool Fan Mtr Loc	Return Fan Mtr Loc	Supply Duct Ht Gn	Supply Duct Loc	Return Air Path
1	4.3		.97	.20			OMIT	OMIT			DUCTED
2	4.3		2.28	.20	.5		OMIT	OMIT			DUCTED
3	5.96			.21			OMIT	OMIT			DUCTED
4	4.37						OMIT	OMIT			DUCTED
5	4.32		1.25	.50			OMIT	OMIT			DUCTED
6	1.68		.50	1.63			OMIT	OMIT			DUCTED
7	9.1		1.45	2.4			OMIT	OMIT			DUCTED

-----CARD 42--- Fan SP and Duct Parameters---

System Set Number	Cool Fan SP	Heat Fan SP	Return Fan SP	Mn Exh Fan SP	Aux Fan SP	Rm Exh Fan SP	Cool Fan Mtr Loc	Return Fan Mtr Loc	Supply Duct Ht Gn	Supply Duct Loc	Return Air Path
8	5.5		.80	1.43			OMIT	OMIT			DUCTED

-----CARD 43-- Airflow Design Temperatures ---

System Set Number	Minimum Cooling SADB	Maximum Cooling SADB	Minimum Heating SADB	Maximum Heating SADB	Minimum Cooling Lv DB	Maximum Cooling Lv DB	Minimum Preheat Lv DB	Maximum Preheat Lv DB	Minimum Room RH	Design Ht Rec Diff
1	50.1	50.1	86	86					45	
2	56	56	86	86						
3	60	60	100	100						
4	60	60	100	100						
5	54	54	86	86						
6	58	58	86	86						
7	56	56	86	86						
8	58	58	86	86						

-----CARD 44-- System Options ---

System Set Number	Econ Type Flag	Econ On Point	Max Pct Outside Air	Direct Evap Cooling	Indirect Evap Cooling	1st Stage Evap Cooling	Fan Cycling	Exhaust Air Heat Recovery — Effectiveness — System	Effectiveness — Room	Control Method — System	Control Method — Room
1								50		COOL	
2											
3											
4											
5								60		CLG-HTG	
6								60		CLG-HTG	
7											
8											

-----CARD 45--- Equipment Schedules ---

System Set Number	Main Cooling Coil	Economizer	Direct Evap Coil	Indirect Evap Coil	Auxiliary Cooling Coil	Main Heating Coil	Main Preheat Coil	Reheat Coil	Mech. Humidity	Auxiliary Heating Coil
1	AVAIL					AVAIL		AVAIL	AVAIL	
2	AVAIL				AVAIL	AVAIL		AVAIL		AVAIL
3	AVAIL					AVAIL				
4	AVAIL					AVAIL				
5	AVAIL					AVAIL				
6	AVAIL					AVAIL				
7	AVAIL					AVAIL				
8	AVAIL					AVAIL				

-----CARD 46--- EMS/BAS Schedules --

System Set Number	Discrim Control Schedule	Night Purge Schedule	Optimum Start Schedule	Optimum Stop Schedule	DUTY CYCLING On Period Schedule	DUTY CYCLING Pattern Length	DUTY CYCLING Maximum Off Time	System HR Exhaust Schedule	Room HR Exhaust Schedule
1								AVAIL	
2								OFF	
3								OFF	
4								OFF	
5								AVAIL	
6								AVAIL	
7								OFF	
8								OFF	

-----CARD 47-- Fan Overrides --

Sys Set Num	Clg Fan Eff	Htg Fan Eff	Ret Fan Eff	Mn Exh Fan Eff	Aux Fan Eff	Rm Exh Fan Eff	Opt Vnt Sys Fan Eff	Mech Eff	MAIN COOLING FAN Air Value	MAIN COOLING FAN Air Units	MAIN COOLING FAN Size Meth	Confg
1	85		85	85								
2	85		85	85	75							
3	75			75								
4	75											
5	85		85	85								
6	85		85	85								
7	85		85	85								
8	85		85	85								

-----CARD 48-- Cooling Capacity Overrides --

System Set Number	People Variance	Lights Variance	Misc Loads Variance	MAIN COOLING Capacity Value	MAIN COOLING Capacity Units	MAIN COOLING Capacity Sizing	MAIN COOLING Capacity Location	AUX COOLING Capacity Value	AUX COOLING Capacity Units
1									
2								100	PCT-CAP
3									
4									
5									
6									
7									
8									

-----CARD 49-- Heating Capacity Overrides --

System Set Number	MAIN HEATING Capacity Value	MAIN HEATING Capacity Units	PREHEAT Capacity Value	PREHEAT Capacity Units	REHEAT Capacity Value	REHEAT Capacity Units	HUMIDIFICATION Capacity Value	HUMIDIFICATION Capacity Units	AUX HEATING Capacity Value	AUX HEATING Capacity Units
1										
2									100	PCT-CAP
3										

-----CARD 49-- Heating Capacity Overrides --

System Set Number	---MAIN HEATING--- Capacity Value	Capacity Units	-----PREHEAT------ Capacity Value	Capacity Units	------REHEAT------ Capacity Value	Capacity Units	--HUMIDIFICATION-- Capacity Value	Capacity Units	---AUX HEATING---- Capacity Value	Capacity Units
4										
5										
6										
7										
8										

-------------------- Equipment Section Alternative #1 --------------------

-----CARD 59-- Equipment Description / TOD Schedules ------------------

Alternative Number	Elec Consump Time of Day Schedule	Elec Demand Time of Day Schedule	Demand Limit Max KW	Alternative Description
1				BASELINE MODEL

-----CARD 60--- Cooling Load Assignment--

Load Asgn Ref	All Coil Loads To Cool Ref	Cooling Equipment Sizing	-Group 1- Begin	End	-Group 2- Begin	End	-Group 3- Begin	End	-Group 4- Begin	End	-Group 5- Begin	End	-Group 6- Begin	End	-Group 7- Begin	End	-Group 8- Begin	End	-Group 9- Begin	End
1	1	BLKPLANT	1	8																

-----CARD 61-- Optional Coil Assignment ------------------------------------

Load Assignment Reference	Main Coil	Direct Evap	Indirect Evap	Aux Coil	Optional Ventil	System Exh Heat Recovery	Room Exh Heat Recovery	Misc. Cooling Load
1				1		1		

-----CARD 62-- Cooling Equipment Parameters --

Cool Ref Num	Equip Code Name	Num of Units	-------------COOLING------------- --Capacity-- Value	Units	----Energy---- Value	Units	---------HEAT RECOVERY---------- --Capacity-- Value	Units	----Energy---- Value	Units	Seq Order Num	Seq Type	Demand Limit Number
1	EQ1008L	1	230	TONS	.86	KW-TON					1		
2	EQ1008L	1	360	TONS	.70	KW-TON					2		
3	EQ1008L	1	230	TONS	.86	KW-TON					3		

-----CARD 63-- Cooling Pumps and References ---

Cool Ref Num	---CHILLED WATER---- Full Load Value	Full Load Units	-----CONDENSER------ Full Load Value	Full Load Units	---HT REC or AUX---- Full Load Value	Full Load Units	Switch-over Control	Cold Storage	Cooling Tower	Misc. Access.
1	50	HP	20	HP			1		1	
2	40	HP	25	HP			1		2	
3	0	HP	20	HP					3	

-----CARD 64-- Cooling Equipment Options ---

Cool Ref Num	Max CW Reset	Load Shed Economizer	Evap Precool	Free Cooling Type	Heat Source	Cond Entering Temp	Cond Min Oper Temp	Cond Rej To Ref Type	Cond Rej To Ref Number	Cond Rej @ HW Temp
1				NONE						
2				NONE						
3				NONE						

-----CARD 65-- Heating Load Assignment ---

Load Assignment Reference	All Coil Loads To Heating Ref	-Group 1- Begin	End	-Group 2- Begin	End	-Group 3- Begin	End	-Group 4- Begin	End	-Group 5- Begin	End	-Group 6- Begin	End	-Group 7- Begin	End	-Group 8- Begin	End	-Group 9- Begin	End
1	1	1	8																

-----CARD 66-- Optional Heating Coil Assignment ---

Load Assignment Reference	Main Coil	Preheat Coil	Reheat Coil	Mech Humidif	Aux Coil	Optional Ventil	Misc. Heating Load
1			1	1	1		

-----CARD 67-- Heating Equipment Parameters ---

Heat Ref Number	Equip Code Name	Number Of Units	HW Pmp Full Ld Value	Units	Cap'y Value	Units	Energy Rate Value	Units	Seq Order Number	Switch over Control	Hot Strg	Misc. Acc.	Cogen	Demand Limit Number
1	EQ2004	1	20	FT-WATER			70	PCTEFF						
2	EQ2004	1	20	FT-WATER			70	PCTEFF						

-----CARD 69-- Fan Equipment Parameters ---

System Set Number	Cooling Fan	Heating Fan	Return Fan	Exhaust Fan	Auxiliary Supply	Room Exhaust	Optional Ventilation
1	EQ4003		EQ4003	EQ4002			
2	EQ4003		EQ4003	EQ4002			
3	EQ4001			EQ4002			
4	EQ4001						
5	EQ4003		EQ4003	EQ4002			
6	EQ4003		EQ4003	EQ4002			

7	EQ4003	EQ4003	EQ4002

-----CARD 69-- Fan Equipment Parameters --

System Set Number	Cooling Fan	Heating Fan	Return Fan	Exhaust Fan	Auxiliary Supply	Room Exhaust	Optional Ventilation
8	EQ4003		EQ4003	EQ4002			

-----CARD 70-- Fan Equipment KW Overrides ----------------------------------

	-----MAIN SYSTEM-----				--OTHER SYSTEM--			----DEMAND LIMIT PRIORITY---				
System Set Number	Cool Fan KW	Heat Fan KW	Ret Fan KW	Exh Fan KW	Aux Sup KW	Room Exh KW	Opt Vent KW	Cool Fan	Heat Fan	Aux Fan	Room Exh Fan	Opt Vent Fan
1	9.6		4.0	0.1								
2	22.5		9.4	0.1								
3	34.7			0.4								
4	31.8											
5	27.3		12.7	3.4								
6	10.2		2.4	4.7								
7	43.1		13.5	3.8								
8	26.0		8.1	2.3								

-----CARD 71-- Base Utility Parameters --

Base Utility Number	Base Utility Descrip	Hourly Demand Value	Hourly Demand Units	Schedule Code	Energy Type	Equip Reference Number	Demand Limiting Number	Entering Temp	Leaving Temp
1	BASE	50	KW	AVAIL	ELEC				
2	BASE DHW	300	GALS	AVAIL	HOT-LD	1		65	134

-----CARD 72-- Switchover Controls ----

Control Reference	Load Value	Load Units	Outside Air DB	Sched Code
1			80	

-----CARD 74--- Condenser / Cooling Tower Parameters --

Tower Ref	Cooling Tower Code	Capacity Value	Capacity Units	Energy Consump Value	Energy Consump Units	Fluid Type	Tower Type	Number of Cells	Percent Airflow Low Spd	Low Spd Energy Value	Low Spd Energy Units
1	EQ5100	230	TONS	20	HP	T-WATER	CTOWER	1			
2	EQ5100	360	TONS	25	HP	T-WATER	CTOWER	1			
3	EQ5100	230	TONS	20	HP	T-WATER	CTOWER	1			

Utility Description Reference Table

Schedules:

AVAIL AVAILABLE (100%)
LITE10 LYSTER ARMY COMMUNITY HOSPITAL
LITE15 LYSTER ARMY COMMUNITY HOSPITAL
LITE26 LYSTER ARMY COMMUNITY HOSPITAL
LITE57 LYSTER ARMY COMMUNITY HOSPITAL
MISC10 LYSTER ARMY COMMUNITY HOSPITAL
MISC15 LYSTER ARMY COMMUNITY HOSPITAL
MISC26 LYSTER ARMY COMMUNITY HOSPITAL
MISC57 LYSTER ARMY COMMUNITY HOSPITAL
OFF ALWAYS OFF
PEOP10 LYSTER ARMY COMMUNITY HOSPITAL
PEOP15 LYSTER ARMY COMMUNITY HOSPITAL
PEOP26 LYSTER ARMY COMMUNITY HOSPITAL
PEOP57 LYSTER ARMY COMMUNITY HOSPITAL
THERM72 LYSTER ARMY COMMUNITY HOSPITAL

System:

BPMZ BYPASS MULTIZONE
DD DOUBLE DUCT
MZ MULTIZONE
TRH TERMINAL REHEAT

Equipment:

Cooling:

EQ1008L 3-STG CTV >200 TONS

Heating:

EQ2004 GAS WATER TUBE STEAM

Fan:

EQ4001 AIRFOIL CENTRIF. FAN C.V.
EQ4002 BI CENTRIF. FAN C.V.
EQ4003 FC CENTRIF. FAN C.V.

Tower:

EQ5100 COOLING TOWER

Schedule Name: AVAIL

Project: AVAILABLE (100)

Location:

Client:

Program User:

Comments:

Starting Month: JAN Ending Month: HTG

Starting Day Type: DSGN Ending Day Type: SUN

Hour	Util Percent
0	100
24	

Schedule Name: LITE10
Project: LYSTER ARMY COMMUNITY HOSPITAL
Location: FORT RUCKER, ALABAMA
Client: U.S. ARMY CORPS OF ENGINEERS
Program User: ENGINEERING RESOURCE GROUP
Comments: LIGHTING SCHEDULE ZONES 1-10

Starting Month: JAN Ending Month: HTG
Starting Day Type: DSGN Ending Day Type: WKDY

Hour	Util Percent
0	20
6	40
7	90
8	100
16	90
17	80
18	20
24	

Starting Month: JAN Ending Month: HTG
Starting Day Type: SAT Ending Day Type: SAT

Hour	Util Percent
0	20
8	50
13	20
24	

Starting Month: JAN Ending Month: HTG
Starting Day Type: SUN Ending Day Type: SUN

Hour	Util Percent
0	20
24	

Schedule Name: LITE15
Project: LYSTER ARMY COMMUNITY HOSPITAL
Location: FORT RUCKER, ALABAMA
Client: U.S. ARMY CORPS OF ENGINEERS
Program User: ENGINEERING RESOURCE GROUP
Comments: LIGHTING SCHEDULE ZONES 11-15

Starting Month: JAN   Ending Month: HTG
Starting Day Type: DSGN   Ending Day Type: SUN

Hour	Util Percent
0	25
5	40
6	50
7	100
15	80
16	50
17	25
24	

Schedule Name: LITE26
Project: LYSTER ARMY COMMUNITY HOSPITAL
Location: FORT RUCKER, ALABAMA
Client: U.S. ARMY CORPS OF ENGINEERS
Program User: ENGINEERING RESOURCE GROUP
Comments: LIGHTING SCHEDULE ZONES 16-26

Starting Month: JAN Ending Month: HTG
Starting Day Type: DSGN Ending Day Type: WKDY

Hour	Util Percent
0	25
6	50
7	100
18	75
21	50
23	25
24	

Starting Month: JAN Ending Month: HTG
Starting Day Type: SAT Ending Day Type: SUN

Hour	Util Percent
0	25
7	50
24	

Schedule Name: LITE57
Project: LYSTER ARMY COMMUNITY HOSPITAL
Location: FORT RUCKER, ALABAMA
Client: U.S. ARMY CORPS OF ENGINEERS
Program User: ENGINEERING RESOURCE GROUP
Comments: LIGHTING SCHEDULE ZONES 27-57

Starting Month: JAN   Ending Month: HTG
Starting Day Type: DSGN   Ending Day Type: WKDY

Hour	Util Percent
0	10
6	50
7	100
18	50
19	10
24	

Starting Month: JAN   Ending Month: HTG
Starting Day Type: SAT   Ending Day Type: SUN

Hour	Util Percent
0	10
8	50
13	10
24	

Schedule Name: MISC10
Project: LYSTER ARMY COMMUNITY HOSPITAL
Location: FORT RUCKER, ALABAMA
Client: U.S. ARMY CORPS OF ENGINEERS
Program User: ENGINEERING RESOURCE GROUP
Comments: MISC. EQUIPMENT SCHEDULE ZONES

Starting Month: JAN   Ending Month: HTG
Starting Day Type: DSGN   Ending Day Type: WKDY

Hour	Util Percent
0	20
6	40
7	80
16	50
18	20
24	

Starting Month: JAN   Ending Month: HTG
Starting Day Type: SAT   Ending Day Type: SAT

Hour	Util Percent
0	25
8	50
13	25
24	

Starting Month: JAN   Ending Month: HTG
Starting Day Type: SUN   Ending Day Type: SUN

Hour	Util Percent
0	25
24	

Schedule Name: MISC15
Project: LYSTER ARMY COMMUNITY HOSPITAL
Location: FORT RUCKER, ALABAMA
Client: U.S. ARMY CORPS OF ENGINEERS
Program User: ENGINEERING RESOURCE GROUP
Comments: MISC. EQUIPMENT SCHEDULE ZONES

Starting Month: JAN Ending Month: HTG
Starting Day Type: DSGN Ending Day Type: SUN

Hour	Util Percent
0	25
7	50
24	

Schedule Name: MISC26
Project: LYSTER ARMY COMMUNITY HOSPITAL
Location: FORT RUCKER, ALABAMA
Client: U.S. ARMY CORPS OF ENGINEERS
Program User: ENGINEERING RESOURCE GROUP
Comments: MISC. EQUIPMENT SCHEDULE ZONES

Starting Month: JAN Ending Month: HTG
Starting Day Type: DSGN Ending Day Type: WKDY

Hour	Util Percent
0	10
6	50
7	100
18	50
19	10
24	

Starting Month: JAN Ending Month: HTG
Starting Day Type: SAT Ending Day Type: SUN

Hour	Util Percent
0	25
7	50
24	

Schedule Name: MISC57
Project: LYSTER ARMY COMMUNITY HOSPITAL
Location: FORT RUCKER, ALABAMA
Client: U.S. ARMY CORPS OF ENGINEERS
Program User: ENGINEERING RESOURCE GROUP
Comments: MISC. EQUIPMENT SCHEDULE ZONES

Starting Month: JAN Ending Month: HTG
Starting Day Type: DSGN Ending Day Type: WKDY

Hour	Util Percent
0	25
7	50
8	75
18	50
19	25
24	

Starting Month: JAN Ending Month: HTG
Starting Day Type: SAT Ending Day Type: SAT

Hour	Util Percent
0	25
8	50
13	25
24	

Starting Month: JAN Ending Month: HTG
Starting Day Type: SUN Ending Day Type: SUN

Hour	Util Percent
0	25
24	

Schedule Name: OFF
Project: ALWAYS OFF
Location:
Client:
Program User:
Comments:

Starting Month: JAN Ending Month: HTG
Starting Day Type: DSGN Ending Day Type: SUN

Hour	Util Percent
0	0
24	

Schedule Name: PEOP10
Project: LYSTER ARMY COMMUNITY HOSPITAL
Location: FORT RUCKER, ALABAMA
Client: U.S. ARMY CORPS OF ENGINEERS
Program User: ENGINEERING RESOURCE GROUP
Comments: PEOPLE SCHEDULE ZONES 1-10

Starting Month: JAN Ending Month: HTG
Starting Day Type: DSGN Ending Day Type: WKDY

Hour	Util Percent
0	10
5	50
6	80
7	100
15	60
16	20
17	10
24	

Starting Month: JAN Ending Month: HTG
Starting Day Type: SAT Ending Day Type: SUN

Hour	Util Percent
0	10
8	50
13	10
24	

Schedule Name: PEOP15
Project: LYSTER ARMY COMMUNITY HOSPITAL
Location: FORT RUCKER, ALABAMA
Client: U.S. ARMY CORPS OF ENGINEERS
Program User: ENGINEERING RESOURCE GROUP
Comments: PEOPLE SCHEDULE ZONES 11-15

Starting Month: JAN Ending Month: HTG
Starting Day Type: DSGN Ending Day Type: SUN

Hour	Util Percent
0	25
5	40
6	50
7	100
15	80
16	50
17	25
24	

Schedule Name: PEOP26
Project: LYSTER ARMY COMMUNITY HOSPITAL
Location: FORT RUCKER, ALABAMA
Client: U.S. ARMY CORPS OF ENGINEERS
Program User: ENGINEERING RESOURCE GROUP
Comments: PEOPLE SCHEDULE ZONES 16-26

Starting Month: JAN Ending Month: HTG
Starting Day Type: DSGN Ending Day Type: WKDY

Hour	Util Percent
0	10
6	50
7	100
18	50
19	10
24	

Starting Month: JAN Ending Month: HTG
Starting Day Type: SAT Ending Day Type: SUN

Hour	Util Percent
0	10
7	25
24	

Schedule Name: PEOP57
Project: LYSTER ARMY COMMUNITY HOSPITAL
Location: FORT RUCKER, ALABAMA
Client: U.S. ARMY CORPS OF ENGINEERS
Program User: ENGINEERING RESOURCE GROUP
Comments: PEOPLE SCHEDULE ZONES 27-57

Starting Month: JAN Ending Month: HTG
Starting Day Type: DSGN Ending Day Type: WKDY

Hour	Util Percent
0	0
5	20
6	40
7	90
8	100
16	90
17	80
18	20
19	0
24	

Starting Month: JAN Ending Month: HTG
Starting Day Type: SAT Ending Day Type: SAT

Hour	Util Percent
0	0
8	50
13	0
24	

Starting Month: JAN Ending Month: HTG
Starting Day Type: SUN Ending Day Type: SUN

Hour	Util Percent
0	0
24	

Schedule Name: THERM72
Project: LYSTER ARMY COMMUNITY HOSPITAL
Location: FORT RUCKER, ALABAMA
Client: U.S. ARMY CORPS OF ENGINEERS
Program User: ENGINEERING RESOURCE GROUP
Comments: THERMOSTAT SCHEDULE FOR 72 DEG

Starting Month: JAN   Ending Month: DEC
Starting Day Type: DSGN   Ending Day Type: SUN

Hour	Temperature
0	72
24	

```
***************************************************************************
***************************************************************************
**                                                                       **
**              T R A C E   6 0 0   A N A L Y S I S                      **
**                                                                       **
**              by            **
**                                                                       **
***************************************************************************
***************************************************************************
```

LYSTER ARMY COMMUNITY HOSPITAL
FORT RUCKER, ALABAMA
U.S. ARMY CORPS OF ENGINEERS
ENGINEERING RESOURCE GROUP, INC.
LIMITED ENERGY STUDIES

Weather File Code:	MOBILE.W	
Location:	FT RUCKER	
Latitude:	30.0	(deg)
Longitude:	88.0	(deg)
Time Zone:	6	
Elevation:	211	(ft)
Barometric Pressure:	29.7	(in. Hg)
Summer Clearness Number:	0.90	
Winter Clearness Number:	0.90	
Summer Design Dry Bulb:	94	(F)
Summer Design Wet Bulb:	80	(F)
Winter Design Dry Bulb:	24	(F)
Summer Ground Relectance:	0.20	
Winter Ground Relectance:	0.20	
Air Density:	0.0754	(Lbm/cuft)
Air Specific Heat:	0.2444	(Btu/lbm/F)
Density-Specific Heat Prod:	1.1064	(Btu-min./hr/cuft/F)
Latent Heat Factor:	4,870.3	(Btu-min./hr/cuft)
Enthalpy Factor:	4.5263	(Lb-min./hr/cuft)

Design Simulation Period: June To November
System Simulation Period: January To December
Cooling Load Methodology: TETD/Time Averaging

Time/Date Program was Run: 17:27: 1 2/16/93
Dataset Name: FTRUCKER .TM

AIRFLOW - ALTERNATIVE 1
BASELINE MODEL

S Y S T E M   S U M M A R Y
(Design Airflow Quantities)

		Main					Auxil.	Room
System Number	System Type	Outside Airflow (Cfm)	Cooling Airflow (Cfm)	Heating Airflow (Cfm)	Return Airflow (Cfm)	Exhaust Airflow (Cfm)	Supply Airflow (Cfm)	Exhaust Airflow (Cfm)
1	BPMZ	11,458	11,458	11,458	11,479	11,479	0	0
2	TRH	9,133	9,133	9,133	9,173	9,173	12,044	0
3	DD	5,124	17,092	17,092	17,112	5,144	0	0
4		4,364	15,507	15,507	19,900	4,364	0	0
5	MZ	3,729	39,850	39,850	39,940	3,819	0	0
6	MZ	6,810	9,026	9,026	9,031	6,815	0	0
7	MZ	10,188	40,833	40,833	40,912	10,267	0	0
8	MZ	3,808	20,562	20,562	20,598	3,844	0	0
Totals		54,614	163,461	163,461	168,146	54,906	12,044	0

CAPACITY - ALTERNATIVE 1
BASELINE MODEL

S Y S T E M   S U M M A R Y
(Design Capacity Quantities)

		Cooling				Heating						
System Number	System Type	Main Sys. Capacity (Tons)	Aux. Sys. Capacity (Tons)	Opt. Vent Capacity (Tons)	Cooling Totals (Tons)	Main Sys. Capacity (Btuh)	Aux. Sys. Capacity (Btuh)	Preheat Capacity (Btuh)	Reheat Capacity (Btuh)	Humidif. Capacity (Btuh)	Opt. Vent Capacity (Btuh)	Heating Totals (Btuh)
1	BPMZ	105.4	0.0	0.0	105.4	-455,108	0	-304,596	0	-342,079	0	-1,101,784
2	TRH	72.1	10.9	0.0	83.0	-303,142	-184,290	-302,407	-132,976	0	0	-789,839
3	DD	57.2	0.0	0.0	57.2	-710,118	0	0	0	0	0	-710,118
4		46.9	0.0	0.0	46.9	-630,718	0	0	0	0	0	-630,718
5	MZ	105.3	0.0	0.0	105.3	-723,917	0	0	0	0	0	-723,917
6	MZ	53.7	0.0	0.0	53.7	-279,618	0	-213,667	0	0	0	-493,285
7	MZ	148.7	0.0	0.0	148.7	-959,030	0	0	0	0	0	-959,030
8	MZ	55.9	0.0	0.0	55.9	-416,548	0	0	0	0	0	-416,548
Totals		645.1	10.9	0.0	656.0	-4,478,199	-184,290	-820,669	-132,976	-342,079	0	-5,825,238

The building peaked at hour 16 month 8 with a capacity of 642.6 tons

ENGINEERING CHECKS - ALTERNATIVE 1
BASELINE MODEL

------------------------------------ E N G I N E E R I N G   C H E C K S ------------------------------------

System Number	Main/ Auxiliary	System Type	Percent Outside Air	Cooling Cfm/ Sq Ft	Cooling Cfm/ Ton	Cooling Sq Ft /Ton	Cooling Btuh/ Sq Ft	Heating Cfm/ Sq Ft	Heating Btuh/ Sq Ft	Floor Area Sq Ft
1	Main	BPMZ	100.00	1.52	108.7	71.5	167.86	1.52	-146.24	7,534
2	Main	TRH	100.00	0.52	126.7	244.1	49.15	0.52	-34.42	17,592
2	Auxiliary	TRH	0.00	0.68	1,102.7	1,610.6	7.45	0.41	-10.48	17,592
3	Main	DD	29.98	0.56	298.7	536.0	22.39	0.56	-23.16	30,667
4	Main		28.14	0.77	330.9	432.3	27.76	0.77	-31.14	20,255
5	Main	MZ	9.36	0.95	378.5	397.0	30.23	0.95	-17.32	41,794
6	Main	MZ	75.45	1.12	168.2	149.8	80.09	1.12	-61.36	8,039
7	Main	MZ	24.95	0.91	274.6	300.2	39.97	0.91	-21.48	44,640
8	Main	MZ	18.52	0.76	367.6	482.1	24.89	0.76	-15.45	26,965

System 1 Block BPMZ - BYPASS MULTIZONE

	COOLING COIL PEAK					CLG SPACE PEAK		HEATING COIL PEAK		
Peaked at Time ==>	Mo/Hr: 8/16					Mo/Hr: 6/14		Mo/Hr: 13/ 1		
Outside Air ==>	OADB/WB/HR: 95/ 81/138.0					OADB: 95		OADB: 24		
Envelope Loads	Space Sens.+Lat. (Btuh)	Ret. Air Sensible (Btuh)	Ret. Air Latent (Btuh)	Net Total (Btuh)	Percnt Of Tot (%)	Space Sensible (Btuh)	Percnt Of Tot (%)	Space Peak Space Sens (Btuh)	Coil Peak Tot Sens (Btuh)	Percnt Of Tot (%)
Skylite Solr	0	0		0	0.00	0	0.00	0	0	0.00
Skylite Cond	0	0		0	0.00	0	0.00	0	0	0.00
Roof Cond	84,542	0		84,542	6.68	99,024	35.67	-48,367	-48,367	6.37
Glass Solar	0	0		0	0.00	0	0.00	0	0	0.00
Glass Cond	0	0		0	0.00	0	0.00	0	0	0.00
Wall Cond	12,073	0		12,073	0.95	10,566	3.81	-21,684	-21,684	2.85
Partition	0			0	0.00	0	0.00	0	0	0.00
Exposed Floor	0			0	0.00	0	0.00	0	0	0.00
Infiltration	1,833			1,833	0.14	534	0.19	-1,126	-1,126	0.15
Sub Total==>	98,447	0		98,447	7.78	110,124	39.67	-71,177	-71,177	9.37
Internal Loads										
Lights	53,239	0		53,239	4.21	59,806	21.54	11,759	11,759	-1.55
People	7,652			7,652	0.61	17,331	6.24	1,711	1,711	-0.23
Misc	3,767	0	0	3,767	0.30	6,024	2.17	1,504	1,504	-0.20
Sub Total==>	64,658	0	0	64,658	5.11	83,161	29.95	14,973	14,973	-1.97
Ceiling Load	0	0		0	0.00	0	0.00	0	0	0.00
Outside Air	0	0	0	990,960	78.36	0	0.00	0	-608,501	80.10
Sup. Fan Heat				26,277	2.08		0.00		26,277	-3.46
Ret. Fan Heat		6,111		6,111	0.48		0.00		0	0.00
Duct Heat Pkup		0		0	0.00		0.00		0	0.00
OV/UNDR Sizing	84,343			84,343	6.67	84,343	30.38	-121,276	-121,276	15.96
Exhaust Heat		-6,111	0	-6,111	-0.48		0.00		0	0.00
Terminal Bypass		0	0	0	-0.00		0.00		0	0.00
Grand Total==>	247,449	0	0	1,264,686	100.00	277,629	100.00	-177,480	-759,704	100.00

COOLING COIL SELECTION

	Total Capacity (Tons)	Total Capacity (Mbh)	Sens Cap. (Mbh)	Coil Airfl (cfm)	Entering DB/WB/HR Deg F	Entering Deg F	Entering Grains	Leaving DB/WB/HR Deg F	Leaving Deg F	Leaving Grains
Main Clg	105.4	1,264.7	558.5	11,458	94.9	80.7	138.0	48.0	46.9	46.3
Aux Clg	0.0	0.0	0.0	0	0.0	0.0	0.0	0.0	0.0	0.0
Opt Vent	0.0	0.0	0.0	0	0.0	0.0	0.0	0.0	0.0	0.0
Totals	105.4	1,264.7								

AREAS

	Gross Total	Glass (sf)	(%)
Floor	7,534		
Part	0		
ExFlr	0		
Roof	7,534	0	0
Wall	2,115	0	0

HEATING COIL SELECTION

	Capacity (Mbh)	Coil Airfl (cfm)	Ent Deg F	Lvg Deg F
Main Htg	-455.1	11,458	50.1	86.0
Aux Htg	0.0	0	0.0	0.0
Preheat	-304.6	11,458	24.0	48.0
Reheat	0.0	0	0.0	0.0
Humidif	-342.1	11,479	10.0	52.8
Opt Vent	0.0	0	0.0	0.0
Total	-1,101.8			

AIRFLOWS (cfm)

Type	Cooling	Heating
Vent	11,458	11,458
Infil	21	21
Supply	11,458	11,458
Mincfm	11,301	11,301
Return	11,458	11,458
Exhaust	11,458	11,458
Rm Exh	0	0
Auxil	0	0

ENGINEERING CHECKS

Clg % OA	100.0
Clg Cfm/Sqft	1.52
Clg Cfm/Ton	108.72
Clg Sqft/Ton	71.49
Clg Btuh/Sqft	167.86
No. People	53
Htg % OA	100.0
Htg Cfm/SqFt	1.52
Htg Btuh/SqFt	-100.84

TEMPERATURES (F)

Type	Clg	Htg
SADB	50.1	86.0
Plenum	72.0	72.0
Return	72.5	72.0
Ret/OA	94.9	24.0
Runarnd	72.0	72.0
Fn MtrTD	0.4	0.0
Fn BldTD	0.5	0.0
Fn Frict	1.6	0.0

System 2 Peak TRH - TERMINAL REHEAT

	COOLING COIL PEAK					CLG SPACE PEAK		HEATING COIL PEAK		
Peaked at Time ==>		Mo/Hr: 7/15				Mo/Hr: 6/14			Mo/Hr: 13/ 1	
Outside Air ==>		OADB/WB/HR: 94/ 80/137.2				OADB: 95			OADB: 24	
	Space Sens.+Lat.	Ret. Air Sensible	Ret. Air Latent	Net Total	Percnt Of Tot	Space Sensible	Percnt Of Tot	Space Peak Space Sens	Coil Peak Tot Sens	Percnt Of Tot
Envelope Loads	(Btuh)	(Btuh)	(Btuh)	(Btuh)	(%)	(Btuh)	(%)	(Btuh)	(Btuh)	(%)
Skylite Solr	0	0		0	0.00	0	0.00	0	0	0.00
Skylite Cond	0	0		0	0.00	0	0.00	0	0	0.00
Roof Cond	163,989	0		163,989	18.97	170,945	105.73	-84,442	-84,442	13.94
Glass Solar	13,786	0		13,786	1.59	17,234	10.66	0	0	0.00
Glass Cond	9,473	0		9,473	1.10	9,570	5.92	-22,029	-22,029	3.64
Wall Cond	22,196	0		22,196	2.57	20,748	12.83	-41,084	-41,084	6.78
Partition	0			0	0.00	0	0.00	0	0	0.00
Exposed Floor	0			0	0.00	0	0.00	0	0	0.00
Infiltration	2,999			2,999	0.35	963	0.60	-2,099	-2,099	0.35
Sub Total==>	212,444	0		212,444	24.57	219,461	135.74	-149,654	-149,654	24.71
Internal Loads										
Lights	32,200	0		32,200	3.72	42,613	26.36	10,653	10,653	-1.76
People	32,823			32,823	3.80	24,224	14.98	6,056	6,056	-1.00
Misc	4,398	0	0	4,398	0.51	4,398	2.72	2,199	2,199	-0.36
Sub Total==>	69,421	0	0	69,421	8.03	71,235	44.06	18,908	18,908	-3.12
Ceiling Load	0	0		0	0.00	0	0.00	0	0	0.00
Outside Air	0	0	0	690,883	79.90	0	0.00	0	-485,027	80.10
Sup. Fan Heat				20,945	2.42		0.00		20,945	-3.46
Ret. Fan Heat		11,203		11,203	1.30		0.00		0	0.00
Duct Heat Pkup		0		0	0.00		0.00		0	0.00
OV/UNDR Sizing	-129,020			-129,020	-14.92	-129,020	-79.80	-10,721	-10,721	1.77
Exhaust Heat		-11,203	0	-11,203	-1.30		0.00		0	0.00
Terminal Bypass		0	0	0	0.00		0.00		0	0.00
Grand Total==>	152,845	0	0	864,673	100.00	161,676	100.00	-141,466	-605,549	100.00

COOLING COIL SELECTION

	Total Capacity (Tons)	Total Capacity (Mbh)	Sens Cap. (Mbh)	Coil Airfl (cfm)	Entering DB Deg F	Entering WB Deg F	Entering HR Grains	Leaving DB Deg F	Leaving WB Deg F	Leaving HR Grains
Main Clg	72.1	864.7	380.5	9,133	94.1	80.5	137.3	53.9	53.1	59.3
Aux Clg	10.9	131.1	131.1	7,258	72.0	60.0	58.9	55.8	53.7	58.6
Opt Vent	0.0	0.0	0.0	0	0.0	0.0	0.0	0.0	0.0	0.0
Totals	83.0	995.7								

AREAS

	Gross Total	Glass (sf)	(%)
Floor	17,592		
Part	0		
ExFlr	0		
Roof	17,592	0	0
Wall	3,552	528	13

HEATING COIL SELECTION

	Capacity (Mbh)	Coil Airfl (cfm)	Ent Deg F	Lvg Deg F
Main Htg	-303.1	9,133	53.9	83.9
Aux Htg	-184.3	12,044	72.0	85.8
Preheat	-302.4	9,133	24.0	53.9
Reheat	-133.0	7,512	56.0	72.0
Humidif	0.0	0	0.0	0.0
Opt Vent	0.0	0	0.0	0.0
Total	-789.8			

AIRFLOWS (cfm)

Type	Cooling	Heating
Vent	9,133	9,133
Infil	40	40
Supply	9,133	9,133
Mincfm	7,512	7,512
Return	9,133	9,133
Exhaust	9,133	9,133
Rm Exh	0	0
Auxil	7,258	12,044

ENGINEERING CHECKS

Clg % OA	100.0
Clg Cfm/Sqft	0.52
Clg Cfm/Ton	126.75
Clg Sqft/Ton	244.14
Clg Btuh/Sqft	49.15
No. People	105
Htg % OA	100.0
Htg Cfm/SqFt	0.52
Htg Btuh/SqFt	-34.42

TEMPERATURES (F)

Type	Clg	Htg
SADB	56.0	86.0
Plenum	72.0	72.0
Return	73.1	72.0
Ret/OA	94.1	24.0
Runarnd	72.0	72.0
Fn MtrTD	0.4	0.0
Fn BldTD	0.5	0.0
Fn Frict	1.6	0.0

System 3 Block DD - DOUBLE DUCT

*** COOLING COIL PEAK ***						CLG SPACE PEAK		HEATING COIL PEAK		
Peaked at Time ==>	Mo/Hr: 8/16					Mo/Hr: 6/15		Mo/Hr: 13/ 1		
Outside Air ==>	OADB/WB/HR: 95/ 81/138.0					OADB: 95		OADB: 24		
Envelope Loads	Space Sens.+Lat. (Btuh)	Ret. Air Sensible (Btuh)	Ret. Air Latent (Btuh)	Net Total (Btuh)	Percnt Of Tot (%)	Space Sensible (Btuh)	Percnt Of Tot (%)	Space Peak Space Sens (Btuh)	Coil Peak Tot Sens (Btuh)	Percnt Of Tot (%)
Skylite Solr	0	0		0	0.00	0	0.00	0	0	0.00
Skylite Cond	0	0		0	0.00	0	0.00	0	0	0.00
Roof Cond	0	49,288		49,288	7.18	0	0.00	0	-26,289	3.53
Glass Solar	13,261	0		13,261	1.93	14,090	6.21	0	0	0.00
Glass Cond	2,194	0		2,194	0.32	2,167	0.96	-4,937	-4,937	0.66
Wall Cond	7,673	0		7,673	1.12	7,386	3.25	-15,792	-15,792	2.12
Partition	0			0	0.00	0	0.00	0	0	0.00
Exposed Floor	0			0	0.00	0	0.00	0	0	0.00
Infiltration	1,451			1,451	0.21	499	0.22	-1,060	-1,060	0.14
Sub Total==>	24,579	49,288		73,867	10.76	24,142	10.64	-21,789	-48,079	6.46
Internal Loads										
Lights	140,446	7,392		147,837	21.53	140,446	61.89	35,111	36,959	-4.96
People	70,383			70,383	10.25	33,725	14.86	3,372	3,372	-0.45
Misc	15,514	0	0	15,514	2.26	13,510	5.95	1,351	1,351	-0.18
Sub Total==>	226,342	7,392	0	233,734	34.04	187,680	82.71	39,835	41,683	-5.60
Ceiling Load	54,385	-54,385		0	0.00	63,204	27.85	-26,640	0	0.00
Outside Air	0	0	0	372,366	54.24	0	0.00	0	-272,121	36.54
Sup. Fan Heat				54,694	7.97		0.00		54,694	-7.34
Ret. Fan Heat		0		0	0.00		0.00		0	0.00
Duct Heat Pkup		0		0	0.00		0.00		0	0.00
OV/UNDR Sizing	-48,099			-48,099	-7.01	-48,099	-21.20	-520,901	-520,901	69.95
Exhaust Heat		0	0	0	0.00		0.00		0	0.00
Terminal Bypass		0	0	0	-0.00		0.00		0	0.00
Grand Total==>	257,207	2,294	0	686,561	100.00	226,927	100.00	-529,495	-744,723	100.00

COOLING COIL SELECTION

	Total Capacity (Tons)	Total Capacity (Mbh)	Sens Cap. (Mbh)	Coil Airfl (cfm)	Entering DB/WB/HR Deg F	Deg F	Grains	Leaving DB/WB/HR Deg F	Deg F	Grains
Main Clg	57.2	686.6	404.4	17,092	78.9	68.8	90.4	57.1	56.4	67.7
Aux Clg	0.0	0.0	0.0	0	0.0	0.0	0.0	0.0	0.0	0.0
Opt Vent	0.0	0.0	0.0	0	0.0	0.0	0.0	0.0	0.0	0.0
Totals	57.2	686.6								

AREAS

	Gross Total	Glass (sf)	(%)
Floor	30,667		
Part	0		
ExFlr	0		
Roof	12,589	0	0
Wall	1,996	118	6

HEATING COIL SELECTION

	Capacity (Mbh)	Coil Airfl (cfm)	Ent Deg F	Lvg Deg F
Main Htg	-710.1	17,092	62.4	100.0
Aux Htg	0.0	0	0.0	0.0
Preheat	-0.0	17,092	57.6	57.1
Reheat	0.0	0	0.0	0.0
Humidif	0.0	0	0.0	0.0
Opt Vent	0.0	0	0.0	0.0
Total	-710.1			

AIRFLOWS (cfm)

Type	Cooling	Heating
Vent	5,124	5,124
Infil	20	20
Supply	17,092	17,092
Mincfm	0	0
Return	17,092	17,092
Exhaust	5,124	5,124
Rm Exh	0	0
Auxil	0	0

ENGINEERING CHECKS

Clg % OA	30.0
Clg Cfm/Sqft	0.56
Clg Cfm/Ton	298.74
Clg Sqft/Ton	536.01
Clg Btuh/Sqft	22.39
No. People	116
Htg % OA	30.0
Htg Cfm/SqFt	0.56
Htg Btuh/SqFt	-23.16

TEMPERATURES (F)

Type	Clg	Htg
SADB	60.0	100.0
Plenum	77.6	69.4
Return	72.0	72.0
Ret/OA	78.9	57.6
Runarnd	72.0	72.0
Fn MtrTD	1.0	0.0
Fn BldTD	0.7	0.0
Fn Frict	2.2	0.0

System 4 Block -

	COOLING COIL PEAK					CLG SPACE PEAK		HEATING COIL PEAK		
Peaked at Time ==>	Mo/Hr: 8/16					Mo/Hr: 6/14		Mo/Hr: 13/ 1		
Outside Air ==>	OADB/WB/HR: 95/ 81/138.0					OADB: 95		OADB: 24		
	Space Sens.+Lat.	Ret. Air Sensible	Ret. Air Latent	Net Total	Percnt Of Tot	Space Sensible	Percnt Of Tot	Space Peak Space Sens	Coil Peak Tot Sens	Percnt Of Tot
Envelope Loads	(Btuh)	(Btuh)	(Btuh)	(Btuh)	(%)	(Btuh)	(%)	(Btuh)	(Btuh)	(%)
Skylite Solr	0	0		0	0.00	0	0.00	0	0	0.00
Skylite Cond	0	0		0	0.00	0	0.00	0	0	0.00
Roof Cond	0	34,673		34,673	6.17	0	0.00	0	-18,888	2.80
Glass Solar	7,686	0		7,686	1.37	40,602	19.72	0	0	0.00
Glass Cond	8,936	0		8,936	1.59	3,515	1.71	-20,008	-20,008	2.97
Wall Cond	17,884	0		17,884	3.18	12,354	6.00	-23,938	-23,938	3.55
Partition	0			0	0.00	0	0.00	0	0	0.00
Exposed Floor	0			0	0.00	0	0.00	0	0	0.00
Infiltration	2,068			2,068	0.37	491	0.24	-1,547	-1,547	0.23
Sub Total==>	36,574	34,673		71,247	12.67	56,961	27.67	-45,492	-64,381	9.55
Internal Loads										
Lights	108,360	5,703		114,063	20.29	108,360	52.63	13,954	14,688	-2.18
People	68,108			68,108	12.11	33,264	16.16	341	341	-0.05
Misc	3,180	0	0	3,180	0.57	3,180	1.54	924	924	-0.14
Sub Total==>	179,648	5,703	0	185,351	32.96	144,803	70.33	15,218	15,953	-2.37
Ceiling Load	46,850	-46,850		0	0.00	44,740	21.73	-19,610	0	0.00
Outside Air	0	0	0	309,926	55.12	0	0.00	0	-231,759	34.37
Sup. Fan Heat				36,390	6.47		0.00		36,390	-5.40
Ret. Fan Heat		0		0	0.00		0.00		0	0.00
Duct Heat Pkup		0		0	0.00		0.00		0	0.00
OV/UNDR Sizing	-40,621			-40,621	-7.22	-40,621	-19.73	-430,510	-430,510	63.84
Exhaust Heat		0	0	0	0.00		0.00		0	0.00
Terminal Bypass		0	0	0	-0.00		0.00		0	0.00
Grand Total==>	222,450	-6,474	0	562,292	100.00	205,883	100.00	-480,394	-674,307	100.00

COOLING COIL SELECTION

	Total Capacity (Tons)	Total Capacity (Mbh)	Sens Cap. (Mbh)	Coil Airfl (cfm)	Entering DB/WB/HR Deg F	Entering Deg F	Entering Grains	Leaving DB/WB/HR Deg F	Leaving Deg F	Leaving Grains
Main Clg	46.9	562.3	323.6	15,507	79.0	68.9	90.8	58.4	57.9	71.7
Aux Clg	0.0	0.0	0.0	0	0.0	0.0	0.0	0.0	0.0	0.0
Opt Vent	0.0	0.0	0.0	0	0.0	0.0	0.0	0.0	0.0	0.0
Totals	46.9	562.3								

AREAS

	Gross Total	Glass (sf)	(%)
Floor	20,255		
Part	0		
ExFlr	0		
Roof	9,053	0	0
Wall	2,512	480	16

HEATING COIL SELECTION

	Capacity (Mbh)	Coil Airfl (cfm)	Ent Deg F	Lvg Deg F
Main Htg	-630.7	15,507	63.2	100.0
Aux Htg	0.0	0	0.0	0.0
Preheat	-0.0	15,507	72.0	57.9
Reheat	0.0	0	0.0	0.0
Humidif	0.0	0	0.0	0.0
Opt Vent	0.0	0	0.0	0.0
Total	-630.7			

AIRFLOWS (cfm)

Type	Cooling	Heating
Vent	4,364	4,364
Infil	29	29
Supply	15,507	15,507
Mincfm	0	0
Return	15,507	15,507
Exhaust	4,364	4,364
Rm Exh	0	0
Auxil	0	0

ENGINEERING CHECKS

Clg % OA	28.1
Clg Cfm/Sqft	0.77
Clg Cfm/Ton	330.94
Clg Sqft/Ton	432.27
Clg Btuh/Sqft	27.76
No. People	96
Htg % OA	28.1
Htg Cfm/SqFt	0.77
Htg Btuh/SqFt	-31.14

TEMPERATURES (F)

Type	Clg	Htg
SADB	60.0	100.0
Plenum	79.3	68.7
Return	72.0	72.0
Ret/OA	78.4	58.5
Runarnd	72.0	72.0
Fn MtrTD	0.7	0.0
Fn BldTD	0.5	0.0
Fn Frict	1.6	0.0

System 5 Block MZ - MULTIZONE

	COOLING COIL PEAK					CLG SPACE PEAK		HEATING COIL PEAK		
Peaked at Time ==>	Mo/Hr: 8/16					Mo/Hr: 6/17		Mo/Hr: 13/ 1		
Outside Air ==>	OADB/WB/HR: 95/ 81/138.0					OADB: 93		OADB: 24		
	Space Sens.+Lat.	Ret. Air Sensible	Ret. Air Latent	Net Total	Percnt Of Tot	Space Sensible	Percnt Of Tot	Space Peak Space Sens	Coil Peak Tot Sens	Percnt Of Tot
Envelope Loads	(Btuh)	(Btuh)	(Btuh)	(Btuh)	(%)	(Btuh)	(%)	(Btuh)	(Btuh)	(%)
Skylite Solr	0	0		0	0.00	0	0.00	0	0	0.00
Skylite Cond	0	0		0	0.00	0	0.00	0	0	0.00
Roof Cond	0	245,971		245,971	19.47	0	0.00	0	-204,533	28.25
Glass Solar	37,600	0		37,600	2.98	51,587	6.51	0	0	0.00
Glass Cond	10,027	0		10,027	0.79	9,408	1.19	-21,800	-21,800	3.01
Wall Cond	35,237	0		35,237	2.79	35,388	4.46	-57,549	-57,549	7.95
Partition	0			0	0.00	0	0.00	0	0	0.00
Exposed Floor	0			0	0.00	0	0.00	0	0	0.00
Infiltration	7,298			7,298	0.58	2,156	0.27	-4,786	-4,786	0.66
Sub Total==>	90,162	245,971		336,132	26.61	98,538	12.43	-84,134	-288,667	39.88
Internal Loads										
Lights	188,299	9,910		198,209	15.69	188,299	23.75	18,015	18,963	-2.62
People	124,644			124,644	9.87	53,626	6.76	0	0	0.00
Misc	4,081	0	0	4,081	0.32	4,081	0.51	1,369	1,369	-0.19
Sub Total==>	317,023	9,910	0	326,934	25.88	246,006	31.03	19,383	20,331	-2.81
Ceiling Load	256,440	-256,440		0	0.00	266,480	33.61	-203,589	0	0.00
Outside Air	0	0	0	302,002	23.90	0	0.00	0	-198,036	27.36
Sup. Fan Heat				91,389	7.23		0.00		91,389	-12.62
Ret. Fan Heat		27,629		27,629	2.19		0.00		0	0.00
Duct Heat Pkup		0		0	0.00		0.00		0	0.00
OV/UNDR Sizing	181,877			181,877	14.40	181,877	22.94	-348,919	-348,919	48.20
Exhaust Heat		-2,585	0	-2,585	-0.20		0.00		0	0.00
Terminal Bypass		0	0	0	-0.00		0.00		0	0.00
Grand Total==>	845,502	24,485	0	1,263,378	100.00	792,901	100.00	-617,260	-723,902	100.00

COOLING COIL SELECTION

	Total Capacity (Tons)	Total Capacity (Mbh)	Sens Cap. (Mbh)	Coil Airfl (cfm)	Entering DB Deg F	Entering WB Deg F	Entering HR Grains	Leaving DB Deg F	Leaving WB Deg F	Leaving HR Grains
Main Clg	105.3	1,263.4	983.7	39,850	74.7	62.4	65.5	51.9	51.0	54.5
Aux Clg	0.0	0.0	0.0	0	0.0	0.0	0.0	0.0	0.0	0.0
Opt Vent	0.0	0.0	0.0	0	0.0	0.0	0.0	0.0	0.0	0.0
Totals	105.3	1,263.4								

AREAS

	Gross Total	Glass (sf)	(%)
Floor	41,794		
Part	0		
ExFlr	0		
Roof	41,794	0	0
Wall	9,011	1,018	11

HEATING COIL SELECTION

	Capacity (Mbh)	Coil Airfl (cfm)	Ent Deg F	Lvg Deg F
Main Htg	-723.9	39,850	69.6	86.0
Aux Htg	0.0	0	0.0	0.0
Preheat	-0.0	39,850	67.5	51.9
Reheat	0.0	0	0.0	0.0
Humidif	0.0	0	0.0	0.0
Opt Vent	0.0	0	0.0	0.0
Total	-723.9			

AIRFLOWS (cfm)

Type	Cooling	Heating
Vent	3,729	3,729
Infil	90	90
Supply	39,850	39,850
Mincfm	0	0
Return	39,850	39,850
Exhaust	3,729	3,725
Rm Exh	0	0
Auxil	0	0

ENGINEERING CHECKS

Clg % OA	9.4
Clg Cfm/Sqft	0.95
Clg Cfm/Ton	378.51
Clg Sqft/Ton	396.97
Clg Btuh/Sqft	30.23
No. People	187
Htg % OA	9.4
Htg Cfm/SqFt	0.95
Htg Btuh/SqFt	-17.32

TEMPERATURES (F)

Type	Clg	Htg
SADB	54.0	86.0
Plenum	91.4	56.6
Return	72.6	72.0
Ret/OA	74.7	67.5
Runarnd	72.0	72.0
Fn MtrTD	0.4	0.0
Fn BldTD	0.5	0.0
Fn Frict	1.6	0.0

System 6 Block MZ - MULTIZONE

************************ COOLING COIL PEAK ****************************** CLG SPACE PEAK ************ HEATING COIL PEAK ********

	COOLING COIL PEAK					CLG SPACE PEAK		HEATING COIL PEAK		
Peaked at Time ==>	Mo/Hr: 8/16					Mo/Hr: 6/17		Mo/Hr: 13/ 1		
Outside Air ==>	OADB/WB/HR: 95/ 81/138.0					OADB: 93		OADB: 24		
Envelope Loads	Space Sens.+Lat. (Btuh)	Ret. Air Sensible (Btuh)	Ret. Air Latent (Btuh)	Net Total (Btuh)	Percnt Of Tot (%)	Space Sensible (Btuh)	Percnt Of Tot (%)	Space Peak Space Sens (Btuh)	Coil Peak Tot Sens (Btuh)	Percnt Of Tot (%)
Skylite Solr	0	0		0	0.00	0	0.00	0	0	0.00
Skylite Cond	0	0		0	0.00	0	0.00	0	0	0.00
Roof Cond	0	47,355		47,355	7.36	0	0.00	0	-39,344	7.98
Glass Solar	0	0		0	0.00	0	0.00	0	0	0.00
Glass Cond	0	0		0	0.00	0	0.00	0	0	0.00
Wall Cond	2,860	0		2,860	0.44	2,705	1.93	-3,557	-3,557	0.72
Partition	0			0	0.00	0	0.00	0	0	0.00
Exposed Floor	0			0	0.00	0	0.00	0	0	0.00
Infiltration	350			350	0.05	117	0.08	-262	-262	0.05
Sub Total==>	3,210	47,355		50,565	7.85	2,822	2.02	-3,819	-43,163	8.75
Internal Loads										
Lights	35,709	1,879		37,589	5.84	35,709	25.54	3,571	3,759	-0.76
People	28,078			28,078	4.36	10,955	7.84	0	0	0.00
Misc	1,206	0	0	1,206	0.19	1,206	0.86	402	402	-0.08
Sub Total==>	64,993	1,879	0	66,873	10.39	47,870	34.24	3,973	4,161	-0.84
Ceiling Load	49,235	-49,235		0	0.00	53,900	38.55	-39,156	0	0.00
Outside Air	0	0	0	482,410	74.93	0	0.00	0	-361,659	73.32
Sup. Fan Heat				8,184	1.27		0.00		8,184	-1.66
Ret. Fan Heat		2,407		2,407	0.37		0.00		0	0.00
Duct Heat Pkup		0		0	0.00		0.00		0	0.00
OV/UNDR Sizing	35,217			35,217	5.47	35,217	25.19	-100,806	-100,806	20.44
Exhaust Heat		-1,816	0	-1,816	-0.28		0.00		0	0.00
Terminal Bypass		0	0	0	-0.00		0.00		0	0.00
Grand Total==>	152,656	591	0	643,840	100.00	139,809	100.00	-139,809	-493,285	100.00

----------------------------------COOLING COIL SELECTION----------------------------------

	Total Capacity (Tons)	Total Capacity (Mbh)	Sens Cap. (Mbh)	Coil Airfl (cfm)	Entering DB/WB/HR Deg F	Entering Deg F	Entering Grains	Leaving DB/WB/HR Deg F	Leaving Deg F	Leaving Grains
Main Clg	53.7	643.8	318.0	9,026	89.3	77.0	122.0	57.2	56.6	68.1
Aux Clg	0.0	0.0	0.0	0	0.0	0.0	0.0	0.0	0.0	0.0
Opt Vent	0.0	0.0	0.0	0	0.0	0.0	0.0	0.0	0.0	0.0
Totals	53.7	643.8								

--------------AREAS--------------

	Gross Total	Glass (sf)	(%)
Floor	8,039		
Part	0		
ExFlr	0		
Roof	8,039	0	0
Wall	494	0	0

------------HEATING COIL SELECTION------------

	Capacity (Mbh)	Coil Airfl (cfm)	Ent Deg F	Lvg Deg F
Main Htg	-279.6	9,026	58.0	86.0
Aux Htg	0.0	0	0.0	0.0
Preheat	-213.7	9,026	35.8	57.2
Reheat	0.0	0	0.0	0.0
Humidif	0.0	0	0.0	0.0
Opt Vent	0.0	0	0.0	0.0
Total	-493.3			

--------AIRFLOWS (cfm)--------

Type	Cooling	Heating
Vent	6,810	6,810
Infil	5	5
Supply	9,026	9,026
Mincfm	0	0
Return	9,026	9,026
Exhaust	6,810	6,810
Rm Exh	0	0
Auxil	0	0

--ENGINEERING CHECKS--

Clg % OA	75.4
Clg Cfm/Sqft	1.12
Clg Cfm/Ton	168.23
Clg Sqft/Ton	149.83
Clg Btuh/Sqft	80.09
No. People	40
Htg % OA	75.4
Htg Cfm/SqFt	1.12
Htg Btuh/SqFt	-61.36

--TEMPERATURES (F)---

Type	Clg	Htg
SADB	58.0	86.0
Plenum	91.3	56.6
Return	72.2	72.0
Ret/OA	89.3	35.8
Runarnd	72.0	72.0
Fn MtrTD	0.1	0.0
Fn BldTD	0.2	0.0
Fn Frict	0.6	0.0

System 7 Block MZ - MULTIZONE

************************ COOLING COIL PEAK ****************************** CLG SPACE PEAK ************ HEATING COIL PEAK ********

	COOLING COIL PEAK					CLG SPACE PEAK		HEATING COIL PEAK		
Peaked at Time ==>	Mo/Hr: 8/16					Mo/Hr: 6/17		Mo/Hr: 13/ 1		
Outside Air ==>	OADB/WB/HR: 95/ 81/138.0					OADB: 93		OADB: 24		
	Space Sens.+Lat.	Ret. Air Sensible	Ret. Air Latent	Net Total	Percnt Of Tot	Space Sensible	Percnt Of Tot	Space Peak Space Sens	Coil Peak Tot Sens	Percnt Of Tot
Envelope Loads	(Btuh)	(Btuh)	(Btuh)	(Btuh)	(%)	(Btuh)	(%)	(Btuh)	(Btuh)	(%)
Skylite Solr	0	0		0	0.00	0	0.00	0	0	0.00
Skylite Cond	0	0		0	0.00	0	0.00	0	0	0.00
Roof Cond	0	262,600		262,600	14.72	0	0.00	0	-218,508	22.40
Glass Solar	12,548	0		12,548	0.70	14,240	1.97	0	0	0.00
Glass Cond	3,718	0		3,718	0.21	3,444	0.48	-8,084	-8,084	0.83
Wall Cond	35,679	0		35,679	2.00	36,828	5.09	-54,471	-54,471	5.58
Partition	0			0	0.00	0	0.00	0	0	0.00
Exposed Floor	0			0	0.00	0	0.00	0	0	0.00
Infiltration	6,411			6,411	0.36	1,872	0.26	-4,218	-4,218	0.43
Sub Total==>	58,355	262,600		320,956	17.99	56,383	7.80	-66,774	-285,281	29.25
Internal Loads										
Lights	215,672	11,351		227,023	12.72	215,672	29.84	21,358	22,482	-2.30
People	62,037			62,037	3.48	24,679	3.41	0	0	0.00
Misc	11,725	0	0	11,725	0.66	10,995	1.52	3,681	3,681	-0.38
Sub Total==>	289,433	11,351	0	300,785	16.86	251,345	34.77	25,038	26,162	-2.68
Ceiling Load	274,156	-274,156		0	0.00	297,487	41.16	-217,377	0	0.00
Outside Air	0	0	0	822,249	46.08	0	0.00	0	-541,055	55.47
Sup. Fan Heat				198,176	11.11		0.00		198,176	-20.32
Ret. Fan Heat		32,666		32,666	1.83		0.00		0	0.00
Duct Heat Pkup		0		0	0.00		0.00		0	0.00
OV/UNDR Sizing	117,626			117,626	6.59	117,626	16.27	-373,373	-373,373	38.2
Exhaust Heat		-8,150	0	-8,150	-0.46		0.00		0	0.00
Terminal Bypass		0	0	0	-0.00		0.00		0	0.00
Grand Total==>	739,570	24,312	0	1,784,308	100.00	722,841	100.00	-632,486	-975,371	100.00

-----------------------------------COOLING COIL SELECTION-----------------------------------

	Total Capacity (Tons)	Total Capacity (Mbh)	Sens Cap. (Mbh)	Coil Airfl (cfm)	Entering DB/WB/HR Deg F	Entering Deg F	Entering Grains	Leaving DB/WB/HR Deg F	Leaving Deg F	Leaving Grains
Main Clg	148.7	1,784.3	1,180.5	40,833	78.3	66.3	78.3	51.6	50.6	53.8
Aux Clg	0.0	0.0	0.0	0	0.0	0.0	0.0	0.0	0.0	0.0
Opt Vent	0.0	0.0	0.0	0	0.0	0.0	0.0	0.0	0.0	0.0
Totals	148.7	1,784.3								

--------------AREAS--------------

Gross Total		Glass (sf)	(%)
Floor	44,640		
Part	0		
ExFlr	0		
Roof	44,640	0	
Wall	7,943	378	

------------HEATING COIL SELECTION------------

	Capacity (Mbh)	Coil Airfl (cfm)	Ent Deg F	Lvg Deg F
Main Htg	-959.0	40,833	64.8	86.0
Aux Htg	0.0	0	0.0	0.0
Preheat	-0.0	40,833	60.0	51.6
Reheat	0.0	0	0.0	0.0
Humidif	0.0	0	0.0	0.0
Opt Vent	0.0	0	0.0	0.0
Total	-959.0			

--------AIRFLOWS (cfm)--------

Type	Cooling	Heating
Vent	10,188	10,188
Infil	79	79
Supply	40,833	40,833
Mincfm	0	0
Return	40,833	40,833
Exhaust	10,188	10,188
Rm Exh	0	0
Auxil	0	0

--ENGINEERING CHECKS--

Clg % OA	25.0
Clg Cfm/Sqft	0.91
Clg Cfm/Ton	274.61
Clg Sqft/Ton	300.22
Clg Btuh/Sqft	39.97
No. People	89
Htg % OA	25.0
Htg Cfm/SqFt	0.91
Htg Btuh/SqFt	-21.48

--TEMPERATURES (F)---

Type	Clg	Htg
SADB	56.0	86.
Plenum	91.4	56.
Return	72.7	72.
Ret/OA	78.3	60.
Runarnd	72.0	72.
Fn MtrTD	0.8	0.
Fn BldTD	1.1	0.
Fn Frict	3.3	0.

Trane Air Conditioning Economics
By: ENGINEERING RESOURCE GROUP, INC.

System 8 Block MZ - MULTIZONE

	COOLING COIL PEAK					CLG SPACE PEAK		HEATING COIL PEAK		
Peaked at Time ==>		Mo/Hr: 8/16				Mo/Hr: 6/17			Mo/Hr: 13/ 1	
Outside Air ==>		OADB/WB/HR: 95/ 81/138.0				OADB: 93			OADB: 24	
	Space Sens.+Lat.	Ret. Air Sensible	Ret. Air Latent	Net Total	Percnt Of Tot	Space Sensible	Percnt Of Tot	Space Peak Space Sens	Coil Peak Tot Sens	Percnt Of Tot
Envelope Loads	(Btuh)	(Btuh)	(Btuh)	(Btuh)	(%)	(Btuh)	(%)	(Btuh)	(Btuh)	(%)
Skylite Solr	0	0		0	0.00	0	0.00	0	0	0.00
Skylite Cond	0	0		0	0.00	0	0.00	0	0	0.00
Roof Cond	0	105,556		105,556	15.73	0	0.00	0	-72,606	16.17
Glass Solar	2,656	0		2,656	0.40	2,746	0.92	0	0	0.00
Glass Cond	1,242	0		1,242	0.19	1,162	0.39	-2,700	-2,700	0.60
Wall Cond	12,715	0		12,715	1.89	15,220	5.11	-25,314	-25,314	5.64
Partition	0			0	0.00	0	0.00	0	0	0.00
Exposed Floor	0			0	0.00	0	0.00	0	0	0.00
Infiltration	2,744			2,744	0.41	863	0.29	-1,934	-1,934	0.43
Sub Total==>	19,357	105,556		124,914	18.61	19,991	6.71	-29,949	-102,555	22.84
Internal Loads										
Lights	119,973	6,314		126,287	18.81	119,973	40.26	11,929	12,557	-2.80
People	43,966			43,966	6.55	19,035	6.39	0	0	0.00
Misc	4,021	0	0	4,021	0.60	4,021	1.35	1,348	1,348	-0.30
Sub Total==>	167,960	6,314	0	174,275	25.96	143,029	48.00	13,278	13,905	-3.10
Ceiling Load	89,962	-89,962		0	0.00	117,349	39.38	-83,351	0	0.00
Outside Air	0	0	0	286,947	42.75	0	0.00	0	-202,232	45.04
Sup. Fan Heat				60,315	8.99		0.00		60,315	-13.43
Ret. Fan Heat		8,773		8,773	1.31		0.00		0	0.00
Duct Heat Pkup		0		0	0.00		0.00		0	0.00
OV/UNDR Sizing	17,636			17,636	2.63	17,636	5.92	-218,474	-218,474	48.65
Exhaust Heat		-1,625	0	-1,625	-0.24		0.00		0	0.00
Terminal Bypass		0	0	0	-0.00		0.00		0	0.00
Grand Total==>	294,916	29,057	0	671,236	100.00	298,004	100.00	-318,497	-449,040	100.00

COOLING COIL SELECTION

	Total Capacity (Tons)	Total Capacity (Mbh)	Sens Cap. (Mbh)	Coil Airfl (cfm)	Entering DB/WB/HR Deg F	Deg F	Grains	Leaving DB/WB/HR Deg F	Deg F	Grains
Main Clg	55.9	671.2	454.5	20,562	76.6	65.9	79.4	56.2	55.5	65.0
Aux Clg	0.0	0.0	0.0	0	0.0	0.0	0.0	0.0	0.0	0.0
Opt Vent	0.0	0.0	0.0	0	0.0	0.0	0.0	0.0	0.0	0.0
Totals	55.9	671.2								

AREAS

	Gross Total	Glass (sf)	(%)
Floor	26,965		
Part	0		
ExFlr	0		
Roof	14,639	0	0
Wall	3,642	126	3

HEATING COIL SELECTION

	Capacity (Mbh)	Coil Airfl (cfm)	Ent Deg F	Lvg Deg F
Main Htg	-416.5	20,562	67.7	86.0
Aux Htg	0.0	0	0.0	0.0
Preheat	-0.0	20,562	63.1	56.2
Reheat	0.0	0	0.0	0.0
Humidif	0.0	0	0.0	0.0
Opt Vent	0.0	0	0.0	0.0
Total	-416.5			

AIRFLOWS (cfm)

Type	Cooling	Heating
Vent	3,808	3,808
Infil	36	36
Supply	20,562	20,562
Mincfm	0	0
Return	20,562	20,562
Exhaust	3,808	3,808
Rm Exh	0	0
Auxil	0	0

ENGINEERING CHECKS

Clg % OA	18.5
Clg Cfm/Sqft	0.76
Clg Cfm/Ton	367.60
Clg Sqft/Ton	482.07
Clg Btuh/Sqft	24.89
No. People	63
Htg % OA	18.5
Htg Cfm/SqFt	0.76
Htg Btuh/SqFt	-15.45

TEMPERATURES (F)

Type	Clg	Htg
SADB	58.9	86.0
Plenum	82.5	63.9
Return	72.4	72.0
Ret/OA	76.6	63.1
Runarnd	72.0	72.0
Fn MtrTD	0.5	0.0
Fn BldTD	0.7	0.0
Fn Frict	2.0	0.0

MAIN SYSTEM COOLING - ALTERNATIVE 1
BASELINE MODEL

PEAK COOLING LOADS

(Main System)

Room Number	Description	Space: Peak Time Mo/Hr	Space: OA Cond. DB/WB (F)	Space: Rm Dry Blb (F)	Space: Supp. Dry Bulb (F)	Space Air Flow (Cfm)	Space Sens. Load (Btuh)	Space Lat. Load (Btuh)	Coil: Peak Time Mo/Hr	Coil: OA Cond. DB/WB (F)	Coil: Rm Dry Blb (F)	Coil: Supp. Dry Bulb (F)	Coil Air Flow (Cfm)	Coil Sens. Load (Btuh)	Coil Lat. Load (Btuh)
1	SURGERY1	6/14	95 78	72	50.1	662	16,040	2,817	7/15	94 80	72	51.3	662	32,826	41,972
Zone	1 Total/Ave.		95 78	72	50.1	662	16,040	2,817		94 80	72	51.3	662	32,826	41,972
Zone	1 Block	6/14	95 78	72	50.1	662	16,040	2,817	7/15	94 80	72	51.3	662	32,826	41,972
2	SUR CORR	6/14	95 78	72	50.1	1,391	33,704	1,474	8/16	95 81	72	51.8	1,391	69,479	85,493
Zone	2 Total/Ave.		95 78	72	50.1	1,391	33,704	1,474		95 81	72	51.8	1,391	69,479	85,493
Zone	2 Block	6/14	95 78	72	50.1	1,391	33,704	1,474	8/16	95 81	72	51.8	1,391	69,479	85,493
3	SURGERY2	6/14	95 78	72	50.1	600	14,538	2,320	7/15	94 80	72	51.5	600	29,619	37,743
Zone	3 Total/Ave.		95 78	72	50.1	600	14,538	2,320		94 80	72	51.5	600	29,619	37,743
Zone	3 Block	6/14	95 78	72	50.1	600	14,538	2,320	7/15	94 80	72	51.5	600	29,619	37,743
4	DEL 1	8/14	95 80	72	50.1	531	12,866	1,963	7/15	94 80	72	51.1	531	26,414	33,469
Zone	4 Total/Ave.		95 80	72	50.1	531	12,866	1,963		94 80	72	51.1	531	26,414	33,469
Zone	4 Block	8/14	95 80	72	50.1	531	12,866	1,963	7/15	94 80	72	51.1	531	26,414	33,469
5	DEL 2	8/14	95 80	72	50.1	474	11,485	1,679	7/15	94 80	72	51.1	474	23,583	29,769
Zone	5 Total/Ave.		95 80	72	50.1	474	11,485	1,679		94 80	72	51.1	474	23,583	29,769
Zone	5 Block	8/14	95 80	72	50.1	474	11,485	1,679	7/15	94 80	72	51.1	474	23,583	29,769
6	LABOR	6/14	95 78	72	50.1	2,543	61,617	4,916	7/15	94 80	72	51.3	2,543	126,051	157,016
Zone	6 Total/Ave.		95 78	72	50.1	2,543	61,617	4,916		94 80	72	51.3	2,543	126,051	157,016
Zone	6 Block	6/14	95 78	72	50.1	2,543	61,617	4,916	7/15	94 80	72	51.3	2,543	126,051	157,016
7	SUR. LOUN	6/14	95 78	72	50.1	2,952	71,527	3,100	8/16	95 81	72	51.9	2,952	147,236	181,398
Zone	7 Total/Ave.		95 78	72	50.1	2,952	71,527	3,100		95 81	72	51.9	2,952	147,236	181,398
Zone	7 Block	6/14	95 78	72	50.1	2,952	71,527	3,100	8/16	95 81	72	51.9	2,952	147,236	181,398
8	NURSERY	6/14	95 78	72	50.1	1,319	31,960	1,494	8/16	95 81	72	52.3	1,319	65,201	80,953
Zone	8 Total/Ave.		95 78	72	50.1	1,319	31,960	1,494		95 81	72	52.3	1,319	65,201	80,953
Zone	8 Block	6/14	95 78	72	50.1	1,319	31,960	1,494	8/16	95 81	72	52.3	1,319	65,201	80,953
9	OB RECOV	8/14	95 80	72	50.1	378	9,159	1,180	8/16	95 81	72	52.7	378	18,534	23,417
Zone	9 Total/Ave.		95 80	72	50.1	378	9,159	1,180		95 81	72	52.7	378	18,534	23,417
Zone	9 Block	8/14	95 80	72	50.1	378	9,159	1,180	8/16	95 81	72	52.7	378	18,534	23,417
10	OR RECOV	6/14	95 78	72	50.1	608	14,732	1,316	8/16	95 81	72	52.9	608	29,646	37,441
Zone	10 Total/Ave.		95 78	72	50.1	608	14,732	1,316		95 81	72	52.9	608	29,646	37,441
Zone	10 Block	6/14	95 78	72	50.1	608	14,732	1,316	8/16	95 81	72	52.9	608	29,646	37,441
System	1 Total/Ave.		95 78	72	50.1	11,458	277,629	22,260		95 81	72	51.7	11,458	568,588	708,672
System	1 Block	6/14	95 78	72	50.1	11,458	277,403	22,188	8/16	95 81	72	52.9	11,458	558,547	706,139
11	PERIM N.	6/14	95 78	72	56.0	2,994	53,001	9,692	7/15	94 80	72	58.6	2,994	124,103	161,171
Zone	11 Total/Ave.		95 78	72	56.0	2,994	53,001	9,692		94 80	72	58.6	2,994	124,103	161,171
Zone	11 Block	6/14	95 78	72	56.0	2,994	53,001	9,692	7/15	94 80	72	58.6	2,994	124,103	161,171
12	PERIM. S	9/14	93 76	72	56.0	1,304	23,084	4,147	8/16	95 81	72	60.6	1,304	52,429	69,846
Zone	12 Total/Ave.		93 76	72	56.0	1,304	23,084	4,147		95 81	72	60.6	1,304	52,429	69,846
Zone	12 Block	9/14	93 76	72	56.0	1,304	23,084	4,147	8/16	95 81	72	60.6	1,304	52,429	69,846
13	INT. N	6/14	95 78	72	56.0	2,121	37,547	3,146	7/15	94 80	72	57.9	2,121	89,607	110,833
Zone	13 Total/Ave.		95 78	72	56.0	2,121	37,547	3,146		94 80	72	57.9	2,121	89,607	110,833
Zone	13 Block	6/14	95 78	72	56.0	2,121	37,547	3,146	7/15	94 80	72	57.9	2,121	89,607	110,833
14	INT. S	6/14	95 78	72	56.0	2,239	39,636	3,321	7/15	94 80	72	57.9	2,239	94,633	117,032
Zone	14 Total/Ave.		95 78	72	56.0	2,239	39,636	3,321		94 80	72	57.9	2,239	94,633	117,032
Zone	14 Block	6/14	95 78	72	56.0	2,239	39,636	3,321	7/15	94 80	72	57.9	2,239	94,633	117,032
15	ICU	6/14	95 78	72	56.0	475	8,409	1,135	7/15	94 80	72	58.5	475	19,749	25,270

Zone	15	Total/Ave.		95	78	72	56.0	475	8,409	1,135		94	80	72	58.5	475	19,749	25,270
Zone	15	Block	6/14	95	78	72	56.0	475	8,409	1,135	7/15	94	80	72	58.5	475	19,749	25,270
System	2	Total/Ave.		95	78	72	56.0	9,133	161,676	21,443		94	80	72	58.5	9,133	380,520	484,153

MAIN SYSTEM COOLING - ALTERNATIVE 1
BASELINE MODEL

PEAK COOLING LOADS
(Main System)

Room Number	Description	Space: Peak Time Mo/Hr	Space: OA Cond. DB (F)	Space: OA Cond. WB (F)	Space: Rm Dry Blb (F)	Space: Supp. Dry Bulb (F)	Space Air Flow (Cfm)	Space Sens. Load (Btuh)	Space Lat. Load (Btuh)	Coil: Peak Time Mo/Hr	Coil: OA Cond. DB (F)	Coil: OA Cond. WB (F)	Coil: Rm Dry Blb (F)	Coil: Supp. Dry Bulb (F)	Coil Air Flow (Cfm)	Coil Sens. Load (Btuh)	Coil Lat. Load (Btuh)
System 2	Block	6/14	95	78	72	56.2	9,133	159,635	21,512	7/15	94	80	72	58.3	9,133	381,973	484,540
16	KIT ADMIN	6/15	95	79	72	60.0	434	5,762	1,316	8/16	95	81	72	60.5	434	5,597	9,457
Zone 16	Total/Ave.		95	79	72	60.0	434	5,762	1,316		95	81	72	60.5	434	5,597	9,457
Zone 16	Block	6/15	95	79	72	60.0	434	5,762	1,316	8/16	95	81	72	60.5	434	5,597	9,457
17	FOOD PRE	6/17	93	77	72	60.0	887	11,777	2,547	8/16	95	81	72	63.4	887	18,985	17,050
Zone 17	Total/Ave.		93	77	72	60.0	887	11,777	2,547		95	81	72	63.4	887	18,985	17,050
Zone 17	Block	6/17	93	77	72	60.0	887	11,777	2,547	8/16	95	81	72	63.4	887	18,985	17,050
18	XRAY EXT	6/14	95	78	72	60.0	2,124	28,200	3,468	8/16	95	81	72	64.2	2,124	47,739	45,689
Zone 18	Total/Ave.		95	78	72	60.0	2,124	28,200	3,468		95	81	72	64.2	2,124	47,739	45,689
Zone 18	Block	6/14	95	78	72	60.0	2,124	28,200	3,468	8/16	95	81	72	64.2	2,124	47,739	45,689
19	XRAY INT	6/14	95	78	72	60.0	1,640	21,774	2,987	8/16	95	81	72	60.0	1,640	41,714	21,763
Zone 19	Total/Ave.		95	78	72	60.0	1,640	21,774	2,987		95	81	72	60.0	1,640	41,714	21,763
Zone 19	Block	6/14	95	78	72	60.0	1,640	21,774	2,987	8/16	95	81	72	60.0	1,640	41,714	21,763
20	PHY THER	6/14	95	78	72	60.0	1,664	22,093	4,668	8/16	95	81	72	64.5	1,664	37,831	39,505
Zone 20	Total/Ave.		95	78	72	60.0	1,664	22,093	4,668		95	81	72	64.5	1,664	37,831	39,505
Zone 20	Block	6/14	95	78	72	60.0	1,664	22,093	4,668	8/16	95	81	72	64.5	1,664	37,831	39,505
21	ADMIN	8/15	95	80	72	60.0	1,214	16,118	4,565	8/16	95	81	72	62.3	1,214	24,458	18,717
Zone 21	Total/Ave.		95	80	72	60.0	1,214	16,118	4,565		95	81	72	62.3	1,214	24,458	18,717
Zone 21	Block	8/15	95	80	72	60.0	1,214	16,118	4,565	8/16	95	81	72	62.3	1,214	24,458	18,717
22	SUR.CLINIC	6/14	95	78	72	60.0	1,421	18,866	3,178	8/16	95	81	72	63.6	1,421	30,933	27,791
Zone 22	Total/Ave.		95	78	72	60.0	1,421	18,866	3,178		95	81	72	63.6	1,421	30,933	27,791
Zone 22	Block	6/14	95	78	72	60.0	1,421	18,866	3,178	8/16	95	81	72	63.6	1,421	30,933	27,791
23	SUR.CLINIC	6/14	95	78	72	60.0	3,555	47,199	7,423	8/16	95	81	72	60.0	3,555	93,715	53,478
Zone 23	Total/Ave.		95	78	72	60.0	3,555	47,199	7,423		95	81	72	60.0	3,555	93,715	53,478
Zone 23	Block	6/14	95	78	72	60.0	3,555	47,199	7,423	8/16	95	81	72	60.0	3,555	93,715	53,478
24	MECH	6/14	95	78	72	60.0	353	4,687	466	8/16	95	81	72	60.2	353	10,261	8,939
Zone 24	Total/Ave.		95	78	72	60.0	353	4,687	466		95	81	72	60.2	353	10,261	8,939
Zone 24	Block	6/14	95	78	72	60.0	353	4,687	466	8/16	95	81	72	60.2	353	10,261	8,939
25	E.R.AC10	6/16	95	79	72	60.0	3,800	50,452	8,741	8/16	95	81	72	60.0	3,800	85,206	39,751
Zone 25	Total/Ave.		95	79	72	60.0	3,800	50,452	8,741		95	81	72	60.0	3,800	85,206	39,751
Zone 25	Block	6/16	95	79	72	60.0	3,800	50,452	8,741	8/16	95	81	72	60.0	3,800	85,206	39,751
System 3	Total/Ave.		95	79	72	60.0	17,092	226,927	39,359		95	81	72	61.6	17,092	400,440	282,139
System 3	Block	6/15	95	79	72	60.1	17,092	224,369	39,431	8/16	95	81	72	60.5	17,092	404,422	282,139
26	ADMIN	6/14	95	78	72	60.0	1,939	25,744	4,298	8/16	95	81	72	60.0	1,939	41,031	33,442
Zone 26	Total/Ave.		95	78	72	60.0	1,939	25,744	4,298		95	81	72	60.0	1,939	41,031	33,442
Zone 26	Block	6/14	95	78	72	60.0	1,939	25,744	4,298	8/16	95	81	72	60.0	1,939	41,031	33,442
27	DENT EXT	8/ 9	84	74	72	60.0	2,417	32,090	2,056	8/16	95	81	72	62.4	2,417	37,908	14,013
Zone 27	Total/Ave.		84	74	72	60.0	2,417	32,090	2,056		95	81	72	62.4	2,417	37,908	14,013
Zone 27	Block	8/ 9	84	74	72	60.0	2,417	32,090	2,056	8/16	95	81	72	62.4	2,417	37,908	14,013
28	DENT INT	6/15	95	79	72	60.0	3,182	42,247	8,554	8/16	95	81	72	63.4	3,182	69,904	65,758
Zone 28	Total/Ave.		95	79	72	60.0	3,182	42,247	8,554		95	81	72	63.4	3,182	69,904	65,758
Zone 28	Block	6/15	95	79	72	60.0	3,182	42,247	8,554	8/16	95	81	72	63.4	3,182	69,904	65,758
29	EENT EXT	8/15	95	80	72	60.0	1,061	14,087	2,646	8/16	95	81	72	60.0	1,061	27,235	17,364
Zone 29	Total/Ave.		95	80	72	60.0	1,061	14,087	2,646		95	81	72	60.0	1,061	27,235	17,364
Zone 29	Block	8/15	95	80	72	60.0	1,061	14,087	2,646	8/16	95	81	72	60.0	1,061	27,235	17,364

	30	EENT INT	6/14	95	78	72	60.0	1,996	26,500	5,359	7/15	94	80	72	60.0	1,996	58,221	41,272
Zone	30	Total/Ave.		95	78	72	60.0	1,996	26,500	5,359		94	80	72	60.0	1,996	58,221	41,272
Zone	30	Block	6/14	95	78	72	60.0	1,996	26,500	5,359	7/15	94	80	72	60.0	1,996	58,221	41,272

MAIN SYSTEM COOLING - ALTERNATIVE 1
BASELINE MODEL

P E A K C O O L I N G L O A D S
(Main System)

Room Number	Description	Peak Time Mo/Hr	Space: OA Cond. DB/WB (F)	Space: Rm Dry Blb (F)	Space: Supp. Dry Bulb (F)	Space Air Flow (Cfm)	Space Sens. Load (Btuh)	Space Lat. Load (Btuh)	Coil: Peak Time Mo/Hr	Coil: OA Cond. DB/WB (F)	Coil: Rm Dry Blb (F)	Coil: Supp. Dry Bulb (F)	Coil Air Flow (Cfm)	Coil Sens. Load (Btuh)	Coil Lat. Load (Btuh)
31	AREA S	6/14	95 78	72	60.0	1,506	19,995	4,698	7/15	94 80	72	60.0	1,506	47,263	36,190
Zone	31 Total/Ave.		95 78	72	60.0	1,506	19,995	4,698		94 80	72	60.0	1,506	47,263	36,190
Zone	31 Block	6/14	95 78	72	60.0	1,506	19,995	4,698	7/15	94 80	72	60.0	1,506	47,263	36,190
32	DINING	6/ 8	80 71	72	60.0	3,406	45,221	15,219	7/15	94 80	72	64.6	3,406	45,042	32,259
Zone	32 Total/Ave.		80 71	72	60.0	3,406	45,221	15,219		94 80	72	64.6	3,406	45,042	32,259
Zone	32 Block	6/ 8	80 71	72	60.0	3,406	45,221	15,219	7/15	94 80	72	64.6	3,406	45,042	32,259
System	4 Total/Ave.		95 78	72	60.0	15,507	205,883	42,829		95 81	72	62.1	15,507	326,604	240,297
System	4 Block	6/14	95 78	72	61.2	15,507	185,628	42,873	8/16	95 81	72	61.3	15,507	323,603	238,688
33	AC8 NORT	6/17	93 77	72	54.0	1,750	34,820	2,206	8/16	95 81	72	54.4	1,750	43,029	10,420
Zone	33 Total/Ave.		93 77	72	54.0	1,750	34,820	2,206		95 81	72	54.4	1,750	43,029	10,420
Zone	33 Block	6/17	93 77	72	54.0	1,750	34,820	2,206	8/16	95 81	72	54.4	1,750	43,029	10,420
34	AC8 EAST	6/16	95 79	72	54.0	2,787	55,453	4,179	8/16	95 81	72	54.0	2,787	69,034	16,143
Zone	34 Total/Ave.		95 79	72	54.0	2,787	55,453	4,179		95 81	72	54.0	2,787	69,034	16,143
Zone	34 Block	6/16	95 79	72	54.0	2,787	55,453	4,179	8/16	95 81	72	54.0	2,787	69,034	16,143
35	AC7 SO	9/15	93 76	72	54.0	5,033	100,142	7,721	8/16	95 81	72	55.4	5,033	118,618	31,851
Zone	35 Total/Ave.		93 76	72	54.0	5,033	100,142	7,721		95 81	72	55.4	5,033	118,618	31,851
Zone	35 Block	9/15	93 76	72	54.0	5,033	100,142	7,721	8/16	95 81	72	55.4	5,033	118,618	31,851
36	AC8 SO	9/15	93 76	72	54.0	3,273	65,123	4,064	8/16	95 81	72	55.7	3,273	73,896	15,380
Zone	36 Total/Ave.		93 76	72	54.0	3,273	65,123	4,064		95 81	72	55.7	3,273	73,896	15,380
Zone	36 Block	9/15	93 76	72	54.0	3,273	65,123	4,064	8/16	95 81	72	55.7	3,273	73,896	15,380
37	AC7 WEST	6/17	93 77	72	54.0	2,571	51,156	2,894	8/17	94 80	72	54.6	2,571	60,891	11,871
Zone	37 Total/Ave.		93 77	72	54.0	2,571	51,156	2,894		94 80	72	54.6	2,571	60,891	11,871
Zone	37 Block	6/17	93 77	72	54.0	2,571	51,156	2,894	8/17	94 80	72	54.6	2,571	60,891	11,871
38	AC7 INT	6/17	93 77	72	54.0	11,929	237,353	18,847	8/16	95 81	72	54.1	11,929	301,834	88,803
Zone	38 Total/Ave.		93 77	72	54.0	11,929	237,353	18,847		95 81	72	54.1	11,929	301,834	88,803
Zone	38 Block	6/17	93 77	72	54.0	11,929	237,353	18,847	8/16	95 81	72	54.1	11,929	301,834	88,803
39	AC8 INT	6/17	93 77	72	54.0	12,507	248,854	26,420	8/16	95 81	72	54.1	12,507	317,752	104,797
Zone	39 Total/Ave.		93 77	72	54.0	12,507	248,854	26,420		95 81	72	54.1	12,507	317,752	104,797
Zone	39 Block	6/17	93 77	72	54.0	12,507	248,854	26,420	8/16	95 81	72	54.1	12,507	317,752	104,797
System	5 Total/Ave.		93 77	72	54.0	39,850	792,901	66,331		95 81	72	54.4	39,850	985,054	279,266
System	5 Block	6/17	93 77	72	54.6	39,850	766,058	63,894	8/16	95 81	72	54.5	39,850	983,740	279,639
40	AC9 LAB	6/17	93 77	72	58.0	9,026	139,809	14,142	8/16	95 81	72	58.3	9,026	318,022	325,818
Zone	40 Total/Ave.		93 77	72	58.0	9,026	139,809	14,142		95 81	72	58.3	9,026	318,022	325,818
Zone	40 Block	6/17	93 77	72	58.0	9,026	139,809	14,142	8/16	95 81	72	58.3	9,026	318,022	325,818
System	6 Total/Ave.		93 77	72	58.0	9,026	139,809	14,142		95 81	72	58.3	9,026	318,022	325,818
System	6 Block	6/17	93 77	72	58.0	9,026	139,809	14,142	8/16	95 81	72	58.3	9,026	318,022	325,818
41	WEST CMS	6/17	93 77	72	56.0	4,592	81,289	4,387	8/16	95 81	72	56.6	4,592	130,992	65,285
Zone	41 Total/Ave.		93 77	72	56.0	4,592	81,289	4,387		95 81	72	56.6	4,592	130,992	65,285
Zone	41 Block	6/17	93 77	72	56.0	4,592	81,289	4,387	8/16	95 81	72	56.6	4,592	130,992	65,285
42	AC11 WES	6/17	93 77	72	56.0	3,884	68,756	2,928	8/16	95 81	72	56.6	3,884	108,824	49,746
Zone	42 Total/Ave.		93 77	72	56.0	3,884	68,756	2,928		95 81	72	56.6	3,884	108,824	49,746
Zone	42 Block	6/17	93 77	72	56.0	3,884	68,756	2,928	8/16	95 81	72	56.6	3,884	108,824	49,746
43	AC14 WES	6/17	93 77	72	56.0	2,056	36,396	1,713	8/16	95 81	72	56.9	2,056	55,915	24,300
Zone	43 Total/Ave.		93 77	72	56.0	2,056	36,396	1,713		95 81	72	56.9	2,056	55,915	24,300
Zone	43 Block	6/17	93 77	72	56.0	2,056	36,396	1,713	8/16	95 81	72	56.9	2,056	55,915	24,300

44	AC13	SOU	9/16	93	76	72	56.0	2,409	42,645	1,780	8/16	95	81	72	56.8	2,409	64,095	24,691
Zone	44	Total/Ave.		93	76	72	56.0	2,409	42,645	1,780		95	81	72	56.8	2,409	64,095	24,691
Zone	44	Block	9/16	93	76	72	56.0	2,409	42,645	1,780	8/16	95	81	72	56.8	2,409	64,095	24,691

MAIN SYSTEM COOLING - ALTERNATIVE 1
BASELINE MODEL

P E A K C O O L I N G L O A D S
(Main System)

Room Number	Description	Space Peak Time Mo/Hr	Space OA Cond. DB/WB (F)	Space Rm Dry Blb (F)	Space Supp. Dry Bulb (F)	Space Air Flow (Cfm)	Space Sens. Load (Btuh)	Space Lat. Load (Btuh)	Coil Peak Time Mo/Hr	Coil OA Cond. DB/WB (F)	Coil Rm Dry Blb (F)	Coil Supp. Dry Bulb (F)	Coil Air Flow (Cfm)	Coil Sens. Load (Btuh)	Coil Lat. Load (Btuh)
45	AC11 EAS	6/17	93 77	72	56.0	2,898	51,301	2,508	8/16	95 81	72	56.3	2,898	83,750	41,637
Zone 45	Total/Ave.		93 77	72	56.0	2,898	51,301	2,508		95 81	72	56.3	2,898	83,750	41,637
Zone 45	Block	6/17	93 77	72	56.0	2,898	51,301	2,508	8/16	95 81	72	56.3	2,898	83,750	41,637
46	AC14 EAS	6/17	93 77	72	56.0	6,608	116,977	4,769	8/16	95 81	72	56.3	6,608	187,794	86,076
Zone 46	Total/Ave.		93 77	72	56.0	6,608	116,977	4,769		95 81	72	56.3	6,608	187,794	86,076
Zone 46	Block	6/17	93 77	72	56.0	6,608	116,977	4,769	8/16	95 81	72	56.3	6,608	187,794	86,076
47	AC13 EAS	6/17	93 77	72	56.0	2,130	37,706	4,506	8/16	95 81	72	56.7	2,130	77,927	72,360
Zone 47	Total/Ave.		93 77	72	56.0	2,130	37,706	4,506		95 81	72	56.7	2,130	77,927	72,360
Zone 47	Block	6/17	93 77	72	56.0	2,130	37,706	4,506	8/16	95 81	72	56.7	2,130	77,927	72,360
48	AC11 INT	6/17	93 77	72	56.0	3,802	67,304	3,083	8/16	95 81	72	56.6	3,802	111,591	60,171
Zone 48	Total/Ave.		93 77	72	56.0	3,802	67,304	3,083		95 81	72	56.6	3,802	111,591	60,171
Zone 48	Block	6/17	93 77	72	56.0	3,802	67,304	3,083	8/16	95 81	72	56.6	3,802	111,591	60,171
49	AC14 INT	6/17	93 77	72	56.0	5,267	93,238	4,056	8/16	95 81	72	56.5	5,267	152,820	78,154
Zone 49	Total/Ave.		93 77	72	56.0	5,267	93,238	4,056		95 81	72	56.5	5,267	152,820	78,154
Zone 49	Block	6/17	93 77	72	56.0	5,267	93,238	4,056	8/16	95 81	72	56.5	5,267	152,820	78,154
50	AC13 INT	6/17	93 77	72	56.0	7,187	127,227	5,197	8/16	95 81	72	56.4	7,187	206,757	101,423
Zone 50	Total/Ave.		93 77	72	56.0	7,187	127,227	5,197		95 81	72	56.4	7,187	206,757	101,423
Zone 50	Block	6/17	93 77	72	56.0	7,187	127,227	5,197	8/16	95 81	72	56.4	7,187	206,757	101,423
System 7	Total/Ave.		93 77	72	56.0	40,833	722,841	34,928		95 81	72	56.5	40,833	1,180,465	603,843
System 7	Block	6/17	93 77	72	56.1	40,833	718,868	34,826	8/16	95 81	72	56.5	40,833	1,180,464	603,843
51	AC17 WES	6/17	93 77	72	58.9	1,332	19,305	950	8/16	95 81	72	59.4	1,332	30,443	9,009
Zone 51	Total/Ave.		93 77	72	58.9	1,332	19,305	950		95 81	72	59.4	1,332	30,443	9,009
Zone 51	Block	6/17	93 77	72	58.9	1,332	19,305	950	8/16	95 81	72	59.4	1,332	30,443	9,009
52	AC17 NOR	6/17	93 77	72	58.9	4,370	63,334	2,993	8/16	95 81	72	58.9	4,370	94,678	26,829
Zone 52	Total/Ave.		93 77	72	58.9	4,370	63,334	2,993		95 81	72	58.9	4,370	94,678	26,829
Zone 52	Block	6/17	93 77	72	58.9	4,370	63,334	2,993	8/16	95 81	72	58.9	4,370	94,678	26,829
53	AC17 INT	6/17	93 77	72	58.9	9,612	139,306	6,302	8/16	95 81	72	58.9	9,612	220,162	70,981
Zone 53	Total/Ave.		93 77	72	58.9	9,612	139,306	6,302		95 81	72	58.9	9,612	220,162	70,981
Zone 53	Block	6/17	93 77	72	58.9	9,612	139,306	6,302	8/16	95 81	72	58.9	9,612	220,162	70,981
54	AC16 INT	6/14	95 78	72	58.9	1,130	16,377	2,852	8/16	95 81	72	69.9	1,130	17,966	25,695
Zone 54	Total/Ave.		95 78	72	58.9	1,130	16,377	2,852		95 81	72	69.9	1,130	17,966	25,695
Zone 54	Block	6/14	95 78	72	58.9	1,130	16,377	2,852	8/16	95 81	72	69.9	1,130	17,966	25,695
55	AC16 NOR	6/17	93 77	72	58.9	298	4,319	653	8/16	95 81	72	68.3	298	4,621	5,588
Zone 55	Total/Ave.		93 77	72	58.9	298	4,319	653		95 81	72	68.3	298	4,621	5,588
Zone 55	Block	6/17	93 77	72	58.9	298	4,319	653	8/16	95 81	72	68.3	298	4,621	5,588
56	AC16	6/15	95 79	72	58.9	2,187	31,696	7,280	8/16	95 81	72	71.9	2,187	32,795	65,598
Zone 56	Total/Ave.		95 79	72	58.9	2,187	31,696	7,280		95 81	72	71.9	2,187	32,795	65,598
Zone 56	Block	6/15	95 79	72	58.9	2,187	31,696	7,280	8/16	95 81	72	71.9	2,187	32,795	65,598
57	AC18	6/17	93 77	72	58.9	1,633	23,667	4,286	8/16	95 81	72	58.9	1,633	35,413	13,082
Zone 57	Total/Ave.		93 77	72	58.9	1,633	23,667	4,286		95 81	72	58.9	1,633	35,413	13,082
Zone 57	Block	6/17	93 77	72	58.9	1,633	23,667	4,286	8/16	95 81	72	58.9	1,633	35,413	13,082
System 8	Total/Ave.		93 77	72	58.9	20,562	298,005	25,316		95 81	72	61.1	20,562	436,076	216,784
System 8	Block	6/17	93 77	72	59.0	20,562	296,397	23,188	8/16	95 81	72	60.2	20,562	454,452	216,784

AUXILIARY SYSTEM COOLING - ALTERNATIVE 1
BASELINE MODEL

PEAK COOLING LOADS
(Auxiliary System)

		Space								Coil							
Room Number	Description	Peak Time Mo/Hr	OA Cond. DB/WB (F)		Rm Dry Blb (F)	Supp. Dry Bulb (F)	Space Air Flow (Cfm)	Space Sens. Load (Btuh)	Space Lat. Load (Btuh)	Peak Time Mo/Hr	OA Cond. DB/WB (F)		Rm Dry Blb (F)	Supp. Dry Bulb (F)	Coil Air Flow (Cfm)	Coil Sens. Load (Btuh)	Coil Lat. Load (Btuh)
11	PERIM N.	6/14	95	78	72	56.0	992	17,561	0	6/14	95	78	72	56.0	992	17,913	0
Zone	11 Total/Ave.		95	78	72	56.0	992	17,561	0		95	78	72	56.0	992	17,913	0
Zone	11 Block	6/14	95	78	72	56.0	992	17,561	0	6/14	95	78	72	56.0	992	17,913	0
12	PERIM. S	8/15	95	80	72	56.0	381	6,745	0	8/15	95	80	72	56.0	381	6,880	0
Zone	12 Total/Ave.		95	80	72	56.0	381	6,745	0		95	80	72	56.0	381	6,880	0
Zone	12 Block	8/15	95	80	72	56.0	381	6,745	0	8/15	95	80	72	56.0	381	6,880	0
13	INT. N	6/14	95	78	72	56.0	2,764	48,935	0	6/14	95	78	72	56.0	2,764	49,918	0
Zone	13 Total/Ave.		95	78	72	56.0	2,764	48,935	0		95	78	72	56.0	2,764	49,918	0
Zone	13 Block	6/14	95	78	72	56.0	2,764	48,935	0	6/14	95	78	72	56.0	2,764	49,918	0
14	INT. S	6/14	95	78	72	56.0	2,918	51,653	0	6/14	95	78	72	56.0	2,918	52,691	0
Zone	14 Total/Ave.		95	78	72	56.0	2,918	51,653	0		95	78	72	56.0	2,918	52,691	0
Zone	14 Block	6/14	95	78	72	56.0	2,918	51,653	0	6/14	95	78	72	56.0	2,918	52,691	0
15	ICU	6/14	95	78	72	56.0	203	3,594	0	6/14	95	78	72	56.0	203	3,666	0
Zone	15 Total/Ave.		95	78	72	56.0	203	3,594	0		95	78	72	56.0	203	3,666	0
Zone	15 Block	6/14	95	78	72	56.0	203	3,594	0	6/14	95	78	72	56.0	203	3,666	0
System	2 Total/Ave.		95	78	72	56.0	7,258	128,487	0		95	78	72	56.0	7,258	131,068	0
System	2 Block	6/14	95	78	72	56.0	7,258	128,098	0	6/14	95	78	72	56.0	7,258	130,679	0

MAIN SYSTEM HEATING - ALTERNATIVE 1
BASELINE MODEL

PEAK HEATING LOADS
(Main System)

Room Number	Description	Floor Area (Sq Ft)	Space: Peak Time Mo/Hr	Space: OA Cond. DB (F)	Space: OA Cond. WB (F)	Space: Rm Dry Blb (F)	Space: Supp. Dry Bulb (F)	Space Air Flow (Cfm)	Space Sens. Load (Btuh)	Coil: Peak Time Mo/Hr	Coil: OA Cond. DB (F)	Coil: OA Cond. WB (F)	Coil: Rm Dry Blb (F)	Coil: Supp. Dry Bulb (F)	Coil Air Flow (Cfm)	Coil Sens. Load (Btuh)
1	SURGERY1	441	13/ 1	24	20	72	86.0	662	-10,254	13/ 1	24	20	72	86.0	662	-26,294
Zone	1 Total/Ave.	441		24	20	72	86.0	662	-10,254		24	20	72	86.0	662	-26,294
Zone	1 Block	441	13/ 1	24	20	72	86.0	662	-10,254	13/ 1	24	20	72	86.0	662	-26,294
2	SUR CORR	927	13/ 1	24	20	72	86.0	1,391	-21,546	13/ 1	24	20	72	86.0	1,391	-55,250
Zone	2 Total/Ave.	927		24	20	72	86.0	1,391	-21,546		24	20	72	86.0	1,391	-55,250
Zone	2 Block	927	13/ 1	24	20	72	86.0	1,391	-21,546	13/ 1	24	20	72	86.0	1,391	-55,250
3	SURGERY2	400	13/ 1	24	20	72	86.0	600	-9,294	13/ 1	24	20	72	86.0	600	-23,832
Zone	3 Total/Ave.	400		24	20	72	86.0	600	-9,294		24	20	72	86.0	600	-23,832
Zone	3 Block	400	13/ 1	24	20	72	86.0	600	-9,294	13/ 1	24	20	72	86.0	600	-23,832
4	DEL 1	294	13/ 1	24	20	72	86.0	531	-8,225	13/ 1	24	20	72	86.0	531	-21,091
Zone	4 Total/Ave.	294		24	20	72	86.0	531	-8,225		24	20	72	86.0	531	-21,091
Zone	4 Block	294	13/ 1	24	20	72	86.0	531	-8,225	13/ 1	24	20	72	86.0	531	-21,091
5	DEL 2	273	13/ 1	24	20	72	86.0	474	-7,342	13/ 1	24	20	72	86.0	474	-18,827
Zone	5 Total/Ave.	273		24	20	72	86.0	474	-7,342		24	20	72	86.0	474	-18,827
Zone	5 Block	273	13/ 1	24	20	72	86.0	474	-7,342	13/ 1	24	20	72	86.0	474	-18,827
6	LABOR	1,695	13/ 1	24	20	72	86.0	2,543	-39,390	13/ 1	24	20	72	86.0	2,543	-101,007
Zone	6 Total/Ave.	1,695		24	20	72	86.0	2,543	-39,390		24	20	72	86.0	2,543	-101,007
Zone	6 Block	1,695	13/ 1	24	20	72	86.0	2,543	-39,390	13/ 1	24	20	72	86.0	2,543	-101,007
7	SUR. LOUN	1,968	13/ 1	24	20	72	86.0	2,952	-45,725	13/ 1	24	20	72	86.0	2,952	-117,253
Zone	7 Total/Ave.	1,968		24	20	72	86.0	2,952	-45,725		24	20	72	86.0	2,952	-117,253
Zone	7 Block	1,968	13/ 1	24	20	72	86.0	2,952	-45,725	13/ 1	24	20	72	86.0	2,952	-117,253
8	NURSERY	879	13/ 1	24	20	72	86.0	1,319	-20,431	13/ 1	24	20	72	86.0	1,319	-52,39
Zone	8 Total/Ave.	879		24	20	72	86.0	1,319	-20,431		24	20	72	86.0	1,319	-52,39
Zone	8 Block	879	13/ 1	24	20	72	86.0	1,319	-20,431	13/ 1	24	20	72	86.0	1,319	-52,39
9	OB RECOV	252	13/ 1	24	20	72	86.0	378	-5,855	13/ 1	24	20	72	86.0	378	-15,01
Zone	9 Total/Ave.	252		24	20	72	86.0	378	-5,855		24	20	72	86.0	378	-15,01
Zone	9 Block	252	13/ 1	24	20	72	86.0	378	-5,855	13/ 1	24	20	72	86.0	378	-15,01
10	OR RECOV	405	13/ 1	24	20	72	86.0	608	-9,418	13/ 1	24	20	72	86.0	608	-24,15
Zone	10 Total/Ave.	405		24	20	72	86.0	608	-9,418		24	20	72	86.0	608	-24,15
Zone	10 Block	405	13/ 1	24	20	72	86.0	608	-9,418	13/ 1	24	20	72	86.0	608	-24,15
System	1 Total/Ave.	7,534		24	20	72	86.0	11,458	-177,480		24	20	72	86.0	11,458	-455,10
System	1 Block	7,534	13/ 1	24	20	72	86.0	11,458	-177,479	13/ 1	24	20	72	86.0	11,458	-455,10
11	PERIM N.	4,644	13/ 1	24	20	72	86.0	2,994	-46,376	13/ 1	24	20	72	86.0	2,994	-99,37
Zone	11 Total/Ave.	4,644		24	20	72	86.0	2,994	-46,376		24	20	72	86.0	2,994	-99,37
Zone	11 Block	4,644	13/ 1	24	20	72	86.0	2,994	-46,376	13/ 1	24	20	72	86.0	2,994	-99,37
12	PERIM. S	1,980	13/ 1	24	20	72	86.0	1,304	-20,198	13/ 1	24	20	72	86.0	1,304	-43,28
Zone	12 Total/Ave.	1,980		24	20	72	86.0	1,304	-20,198		24	20	72	86.0	1,304	-43,28
Zone	12 Block	1,980	13/ 1	24	20	72	86.0	1,304	-20,198	13/ 1	24	20	72	86.0	1,304	-43,28
13	INT. N	4,968	13/ 1	24	20	72	86.0	2,121	-32,853	13/ 1	24	20	72	86.0	2,121	-70,40
Zone	13 Total/Ave.	4,968		24	20	72	86.0	2,121	-32,853		24	20	72	86.0	2,121	-70,40
Zone	13 Block	4,968	13/ 1	24	20	72	86.0	2,121	-32,853	13/ 1	24	20	72	86.0	2,121	-70,40
14	INT. S	5,244	13/ 1	24	20	72	86.0	2,239	-34,681	13/ 1	24	20	72	86.0	2,239	-74,31
Zone	14 Total/Ave.	5,244		24	20	72	86.0	2,239	-34,681		24	20	72	86.0	2,239	-74,31
Zone	14 Block	5,244	13/ 1	24	20	72	86.0	2,239	-34,681	13/ 1	24	20	72	86.0	2,239	-74,31
15	ICU	756	13/ 1	24	20	72	86.0	475	-7,358	13/ 1	24	20	72	86.0	475	-15,7

Zone	15	Total/Ave.	756		24	20	72	86.0	475	-7,358		24	20	72	86.0	475	-15,766
Zone	15	Block	756	13/ 1	24	20	72	86.0	475	-7,358	13/ 1	24	20	72	86.0	475	-15,766
System	2	Total/Ave.	17,592		24	20	72	86.0	9,133	-141,466		24	20	72	86.0	9,133	-303,142

MAIN SYSTEM HEATING - ALTERNATIVE 1
BASELINE MODEL

P E A K   H E A T I N G   L O A D S

(Main System)

Room Number	Description	Floor Area (Sq Ft)	Space: Peak Time Mo/Hr	Space: OA Cond. DB/WB (F)	Space: Rm Dry Blb (F)	Space: Supp. Dry Bulb (F)	Space Air Flow (Cfm)	Space Sens. Load (Btuh)	Coil: Peak Time Mo/Hr	Coil: OA Cond. DB/WB (F)	Coil: Rm Dry Blb (F)	Coil: Supp. Dry Bulb (F)	Coil Air Flow (Cfm)	Coil Sens. Load (Btuh)
System	2 Block	17,592	13/ 1	24 20	72	86.0	9,133	-141,466	13/ 1	24 20	72	86.0	9,133	-303,142
16	KIT ADMIN	1,032	13/ 1	24 20	72	100.0	434	-13,445	13/ 1	24 20	72	100.0	434	-19,207
Zone	16 Total/Ave.	1,032		24 20	72	100.0	434	-13,445		24 20	72	100.0	434	-19,207
Zone	16 Block	1,032	13/ 1	24 20	72	100.0	434	-13,445	13/ 1	24 20	72	100.0	434	-19,207
17	FOOD PRE	1,828	13/ 1	24 20	72	100.0	887	-27,479	13/ 1	24 20	72	98.3	887	-37,548
Zone	17 Total/Ave.	1,828		24 20	72	100.0	887	-27,479		24 20	72	98.3	887	-37,548
Zone	17 Block	1,828	13/ 1	24 20	72	100.0	887	-27,479	13/ 1	24 20	72	98.3	887	-37,548
18	XRAY EXT	5,336	13/ 1	24 20	72	100.0	2,124	-65,800	13/ 1	24 20	72	97.9	2,124	-89,080
Zone	18 Total/Ave.	5,336		24 20	72	100.0	2,124	-65,800		24 20	72	97.9	2,124	-89,080
Zone	18 Block	5,336	13/ 1	24 20	72	100.0	2,124	-65,800	13/ 1	24 20	72	97.9	2,124	-89,080
19	XRAY INT	2,352	13/ 1	24 20	72	100.0	1,640	-50,806	13/ 1	24 20	72	101.5	1,640	-69,116
Zone	19 Total/Ave.	2,352		24 20	72	100.0	1,640	-50,806		24 20	72	101.5	1,640	-69,116
Zone	19 Block	2,352	13/ 1	24 20	72	100.0	1,640	-50,806	13/ 1	24 20	72	101.5	1,640	-69,116
20	PHY THER	4,404	13/ 1	24 20	72	100.0	1,664	-51,549	13/ 1	24 20	72	97.8	1,664	-69,606
Zone	20 Total/Ave.	4,404		24 20	72	100.0	1,664	-51,549		24 20	72	97.8	1,664	-69,606
Zone	20 Block	4,404	13/ 1	24 20	72	100.0	1,664	-51,549	13/ 1	24 20	72	97.8	1,664	-69,606
21	ADMIN	1,790	13/ 1	24 20	72	100.0	1,214	-37,609	13/ 1	24 20	72	98.7	1,214	-47,906
Zone	21 Total/Ave.	1,790		24 20	72	100.0	1,214	-37,609		24 20	72	98.7	1,214	-47,906
Zone	21 Block	1,790	13/ 1	24 20	72	100.0	1,214	-37,609	13/ 1	24 20	72	98.7	1,214	-47,906
22	SUR.CLINIC	3,116	13/ 1	24 20	72	100.0	1,421	-44,021	13/ 1	24 20	72	98.2	1,421	-59,989
Zone	22 Total/Ave.	3,116		24 20	72	100.0	1,421	-44,021		24 20	72	98.2	1,421	-59,989
Zone	22 Block	3,116	13/ 1	24 20	72	100.0	1,421	-44,021	13/ 1	24 20	72	98.2	1,421	-59,989
23	SUR.CLINIC	5,822	13/ 1	24 20	72	100.0	3,555	-110,131	13/ 1	24 20	72	101.7	3,555	-157,091
Zone	23 Total/Ave.	5,822		24 20	72	100.0	3,555	-110,131		24 20	72	101.7	3,555	-157,091
Zone	23 Block	5,822	13/ 1	24 20	72	100.0	3,555	-110,131	13/ 1	24 20	72	101.7	3,555	-157,091
24	MECH	1,072	13/ 1	24 20	72	100.0	353	-10,936	13/ 1	24 20	72	100.4	353	-15,76
Zone	24 Total/Ave.	1,072		24 20	72	100.0	353	-10,936		24 20	72	100.4	353	-15,76
Zone	24 Block	1,072	13/ 1	24 20	72	100.0	353	-10,936	13/ 1	24 20	72	100.4	353	-15,76
25	E.R.AC10	3,915	13/ 1	24 20	72	100.0	3,800	-117,721	13/ 1	24 20	72	101.1	3,800	-144,80
Zone	25 Total/Ave.	3,915		24 20	72	100.0	3,800	-117,721		24 20	72	101.1	3,800	-144,80
Zone	25 Block	3,915	13/ 1	24 20	72	100.0	3,800	-117,721	13/ 1	24 20	72	101.1	3,800	-144,80
System	3 Total/Ave.	30,667		24 20	72	100.0	17,092	-529,496		24 20	72	99.9	17,092	-710,11
System	3 Block	30,667	13/ 1	24 20	72	100.0	17,092	-529,495	13/ 1	24 20	72	99.9	17,092	-745,67
26	ADMIN	2,964	13/ 1	24 20	72	100.0	1,939	-60,069	13/ 1	24 20	72	100.0	1,939	-85,81
Zone	26 Total/Ave.	2,964		24 20	72	100.0	1,939	-60,069		24 20	72	100.0	1,939	-85,81
Zone	26 Block	2,964	13/ 1	24 20	72	100.0	1,939	-60,069	13/ 1	24 20	72	100.0	1,939	-85,81
27	DENT EXT	1,210	13/ 1	24 20	72	100.0	2,417	-74,877	13/ 1	24 20	72	100.0	2,417	-83,19
Zone	27 Total/Ave.	1,210		24 20	72	100.0	2,417	-74,877		24 20	72	100.0	2,417	-83,19
Zone	27 Block	1,210	13/ 1	24 20	72	100.0	2,417	-74,877	13/ 1	24 20	72	100.0	2,417	-83,19
28	DENT INT	5,899	13/ 1	24 20	72	100.0	3,182	-98,576	13/ 1	24 20	72	98.3	3,182	-134,93
Zone	28 Total/Ave.	5,899		24 20	72	100.0	3,182	-98,576		24 20	72	98.3	3,182	-134,93
Zone	28 Block	5,899	13/ 1	24 20	72	100.0	3,182	-98,576	13/ 1	24 20	72	98.3	3,182	-134,93
29	EENT EXT	1,512	13/ 1	24 20	72	100.0	1,061	-32,869	13/ 1	24 20	72	101.4	1,061	-48,59
Zone	29 Total/Ave.	1,512		24 20	72	100.0	1,061	-32,869		24 20	72	101.4	1,061	-48,59
Zone	29 Block	1,512	13/ 1	24 20	72	100.0	1,061	-32,869	13/ 1	24 20	72	101.4	1,061	-48,59

	30	EENT INT	3,696	13/ 1	24	20	72	100.0	1,996	-61,834	13/ 1	24	20	72	101.8	1,996	-92,342
Zone	30	Total/Ave.	3,696		24	20	72	100.0	1,996	-61,834		24	20	72	101.8	1,996	-92,342
Zone	30	Block	3,696	13/ 1	24	20	72	100.0	1,996	-61,834	13/ 1	24	20	72	101.8	1,996	-92,342

MAIN SYSTEM HEATING - ALTERNATIVE 1
BASELINE MODEL

PEAK HEATING LOADS
(Main System)

Room Number	Description	Floor Area (Sq Ft)	Space Peak Time Mo/Hr	Space OA Cond. DB/WB (F)		Space Rm Dry Blb (F)	Space Supp. Dry Bulb (F)	Space Air Flow (Cfm)	Space Sens. Load (Btuh)	Coil Peak Time Mo/Hr	Coil OA Cond. DB/WB (F)		Coil Rm Dry Blb (F)	Coil Supp. Dry Bulb (F)	Coil Air Flow (Cfm)	Coil Sens. Load (Btuh)
31	AREA S	3,240	13/ 1	24	20	72	100.0	1,506	-46,655	13/ 1	24	20	72	102.1	1,506	-70,160
Zone	31 Total/Ave.	3,240		24	20	72	100.0	1,506	-46,655		24	20	72	102.1	1,506	-70,160
Zone	31 Block	3,240	13/ 1	24	20	72	100.0	1,506	-46,655	13/ 1	24	20	72	102.1	1,506	-70,160
32	DINING	1,734	13/ 1	24	20	72	100.0	3,406	-105,515	13/ 1	24	20	72	99.5	3,406	-115,672
Zone	32 Total/Ave.	1,734		24	20	72	100.0	3,406	-105,515		24	20	72	99.5	3,406	-115,672
Zone	32 Block	1,734	13/ 1	24	20	72	100.0	3,406	-105,515	13/ 1	24	20	72	99.5	3,406	-115,672
System	4 Total/Ave.	20,255		24	20	72	100.0	15,507	-480,394		24	20	72	100.1	15,507	-630,718
System	4 Block	20,255	13/ 1	24	20	72	100.0	15,507	-480,393	13/ 1	24	20	72	100.1	15,507	-677,456
33	AC8 NORT	1,579	13/ 1	24	20	72	86.0	1,750	-27,107	13/ 1	24	20	72	86.0	1,750	-30,582
Zone	33 Total/Ave.	1,579		24	20	72	86.0	1,750	-27,107		24	20	72	86.0	1,750	-30,582
Zone	33 Block	1,579	13/ 1	24	20	72	86.0	1,750	-27,107	13/ 1	24	20	72	86.0	1,750	-30,582
34	AC8 EAST	2,367	13/ 1	24	20	72	86.0	2,787	-43,169	13/ 1	24	20	72	86.0	2,787	-47,977
Zone	34 Total/Ave.	2,367		24	20	72	86.0	2,787	-43,169		24	20	72	86.0	2,787	-47,977
Zone	34 Block	2,367	13/ 1	24	20	72	86.0	2,787	-43,169	13/ 1	24	20	72	86.0	2,787	-47,977
35	AC7 SO	4,967	13/ 1	24	20	72	86.0	5,033	-77,959	13/ 1	24	20	72	86.0	5,033	-89,948
Zone	35 Total/Ave.	4,967		24	20	72	86.0	5,033	-77,959		24	20	72	86.0	5,033	-89,948
Zone	35 Block	4,967	13/ 1	24	20	72	86.0	5,033	-77,959	13/ 1	24	20	72	86.0	5,033	-89,948
36	AC8 SO	2,268	13/ 1	24	20	72	86.0	3,273	-50,697	13/ 1	24	20	72	86.0	3,273	-53,908
Zone	36 Total/Ave.	2,268		24	20	72	86.0	3,273	-50,697		24	20	72	86.0	3,273	-53,908
Zone	36 Block	2,268	13/ 1	24	20	72	86.0	3,273	-50,697	13/ 1	24	20	72	86.0	3,273	-53,908
37	AC7 WEST	1,772	13/ 1	24	20	72	86.0	2,571	-39,824	13/ 1	24	20	72	86.0	2,571	-42,308
Zone	37 Total/Ave.	1,772		24	20	72	86.0	2,571	-39,824		24	20	72	86.0	2,571	-42,308
Zone	37 Block	1,772	13/ 1	24	20	72	86.0	2,571	-39,824	13/ 1	24	20	72	86.0	2,571	-42,308
38	AC7 INT	13,657	13/ 1	24	20	72	86.0	11,929	-184,775	13/ 1	24	20	72	86.0	11,929	-222,137
Zone	38 Total/Ave.	13,657		24	20	72	86.0	11,929	-184,775		24	20	72	86.0	11,929	-222,137
Zone	38 Block	13,657	13/ 1	24	20	72	86.0	11,929	-184,775	13/ 1	24	20	72	86.0	11,929	-222,137
39	AC8 INT	15,184	13/ 1	24	20	72	86.0	12,507	-193,728	13/ 1	24	20	72	86.0	12,507	-237,057
Zone	39 Total/Ave.	15,184		24	20	72	86.0	12,507	-193,728		24	20	72	86.0	12,507	-237,057
Zone	39 Block	15,184	13/ 1	24	20	72	86.0	12,507	-193,728	13/ 1	24	20	72	86.0	12,507	-237,057
System	5 Total/Ave.	41,794		24	20	72	86.0	39,850	-617,260		24	20	72	86.0	39,850	-723,917
System	5 Block	41,794	13/ 1	24	20	72	86.0	39,850	-617,259	13/ 1	24	20	72	86.0	39,850	-723,917
40	AC9 LAB	8,039	13/ 1	24	20	72	86.0	9,026	-139,809	13/ 1	24	20	72	86.0	9,026	-279,618
Zone	40 Total/Ave.	8,039		24	20	72	86.0	9,026	-139,809		24	20	72	86.0	9,026	-279,618
Zone	40 Block	8,039	13/ 1	24	20	72	86.0	9,026	-139,809	13/ 1	24	20	72	86.0	9,026	-279,618
System	6 Total/Ave.	8,039		24	20	72	86.0	9,026	-139,809		24	20	72	86.0	9,026	-279,618
System	6 Block	8,039	13/ 1	24	20	72	86.0	9,026	-139,809	13/ 1	24	20	72	86.0	9,026	-279,618
41	WEST CHS	4,776	13/ 1	24	20	72	86.0	4,592	-71,128	13/ 1	24	20	72	86.0	4,592	-106,728
Zone	41 Total/Ave.	4,776		24	20	72	86.0	4,592	-71,128		24	20	72	86.0	4,592	-106,728
Zone	41 Block	4,776	13/ 1	24	20	72	86.0	4,592	-71,128	13/ 1	24	20	72	86.0	4,592	-106,728
42	AC11 WES	3,671	13/ 1	24	20	72	86.0	3,884	-60,162	13/ 1	24	20	72	86.0	3,884	-85,810
Zone	42 Total/Ave.	3,671		24	20	72	86.0	3,884	-60,162		24	20	72	86.0	3,884	-85,810
Zone	42 Block	3,671	13/ 1	24	20	72	86.0	3,884	-60,162	13/ 1	24	20	72	86.0	3,884	-85,810
43	AC14 WES	1,763	13/ 1	24	20	72	86.0	2,056	-31,847	13/ 1	24	20	72	86.0	2,056	-43,215
Zone	43 Total/Ave.	1,763		24	20	72	86.0	2,056	-31,847		24	20	72	86.0	2,056	-43,215
Zone	43 Block	1,763	13/ 1	24	20	72	86.0	2,056	-31,847	13/ 1	24	20	72	86.0	2,056	-43,215

	44	AC13 SOU	1,798	13/ 1	24	20	72	86.0	2,409	-37,314	13/ 1	24	20	72	86.0	2,409	-47,380
Zone	44	Total/Ave.	1,798		24	20	72	86.0	2,409	-37,314		24	20	72	86.0	2,409	-47,380
Zone	44	Block	1,798	13/ 1	24	20	72	86.0	2,409	-37,314	13/ 1	24	20	72	86.0	2,409	-47,380

MAIN SYSTEM HEATING - ALTERNATIVE 1
BASELINE MODEL

P E A K   H E A T I N G   L O A D S
(Main System)

Room Number	Description	Floor Area (Sq Ft)	Space: Peak Time Mo/Hr	Space: OA Cond. DB (F)	Space: OA Cond. WB (F)	Space: Rm Dry Blb (F)	Space: Supp. Dry Bulb (F)	Space Air Flow (Cfm)	Space Sens. Load (Btuh)	Coil: Peak Time Mo/Hr	Coil: OA Cond. DB (F)	Coil: OA Cond. WB (F)	Coil: Rm Dry Blb (F)	Coil: Supp. Dry Bulb (F)	Coil Air Flow (Cfm)	Coil Sens. Load (Btuh)
45	AC11 EAS	3,067	13/ 1	24	20	72	86.0	2,898	-44,889	13/ 1	24	20	72	86.0	2,898	-68,019
Zone	45 Total/Ave.	3,067		24	20	72	86.0	2,898	-44,889		24	20	72	86.0	2,898	-68,019
Zone	45 Block	3,067	13/ 1	24	20	72	86.0	2,898	-44,889	13/ 1	24	20	72	86.0	2,898	-68,019
46	AC14 EAS	6,380	13/ 1	24	20	72	86.0	6,608	-102,355	13/ 1	24	20	72	86.0	6,608	-147,591
Zone	46 Total/Ave.	6,380		24	20	72	86.0	6,608	-102,355		24	20	72	86.0	6,608	-147,591
Zone	46 Block	6,380	13/ 1	24	20	72	86.0	6,608	-102,355	13/ 1	24	20	72	86.0	6,608	-147,591
47	AC13 EAS	5,310	13/ 1	24	20	72	86.0	2,130	-32,993	13/ 1	24	20	72	86.0	2,130	-70,677
Zone	47 Total/Ave.	5,310		24	20	72	86.0	2,130	-32,993		24	20	72	86.0	2,130	-70,677
Zone	47 Block	5,310	13/ 1	24	20	72	86.0	2,130	-32,993	13/ 1	24	20	72	86.0	2,130	-70,677
48	AC11 INT	4,485	13/ 1	24	20	72	86.0	3,802	-58,891	13/ 1	24	20	72	86.0	3,802	-94,845
Zone	48 Total/Ave.	4,485		24	20	72	86.0	3,802	-58,891		24	20	72	86.0	3,802	-94,845
Zone	48 Block	4,485	13/ 1	24	20	72	86.0	3,802	-58,891	13/ 1	24	20	72	86.0	3,802	-94,845
49	AC14 INT	5,828	13/ 1	24	20	72	86.0	5,267	-81,584	13/ 1	24	20	72	86.0	5,267	-126,665
Zone	49 Total/Ave.	5,828		24	20	72	86.0	5,267	-81,584		24	20	72	86.0	5,267	-126,665
Zone	49 Block	5,828	13/ 1	24	20	72	86.0	5,267	-81,584	13/ 1	24	20	72	86.0	5,267	-126,665
50	AC13 INT	7,562	13/ 1	24	20	72	86.0	7,187	-111,324	13/ 1	24	20	72	86.0	7,187	-168,099
Zone	50 Total/Ave.	7,562		24	20	72	86.0	7,187	-111,324		24	20	72	86.0	7,187	-168,099
Zone	50 Block	7,562	13/ 1	24	20	72	86.0	7,187	-111,324	13/ 1	24	20	72	86.0	7,187	-168,099
System	7 Total/Ave.	44,640		24	20	72	86.0	40,833	-632,486		24	20	72	86.0	40,833	-959,03
System	7 Block	44,640	13/ 1	24	20	72	86.0	40,833	-632,486	13/ 1	24	20	72	86.0	40,833	-975,35
51	AC17 WES	1,119	13/ 1	24	20	72	86.0	1,332	-20,632	13/ 1	24	20	72	86.0	1,332	-25,11
Zone	51 Total/Ave.	1,119		24	20	72	86.0	1,332	-20,632		24	20	72	86.0	1,332	-25,11
Zone	51 Block	1,119	13/ 1	24	20	72	86.0	1,332	-20,632	13/ 1	24	20	72	86.0	1,332	-25,11
52	AC17 NOR	3,295	13/ 1	24	20	72	86.0	4,370	-67,689	13/ 1	24	20	72	87.2	4,370	-85,40
Zone	52 Total/Ave.	3,295		24	20	72	86.0	4,370	-67,689		24	20	72	87.2	4,370	-85,40
Zone	52 Block	3,295	13/ 1	24	20	72	86.0	4,370	-67,689	13/ 1	24	20	72	87.2	4,370	-85,40
53	AC17 INT	9,055	13/ 1	24	20	72	86.0	9,612	-148,886	13/ 1	24	20	72	87.5	9,612	-204,72
Zone	53 Total/Ave.	9,055		24	20	72	86.0	9,612	-148,886		24	20	72	87.5	9,612	-204,72
Zone	53 Block	9,055	13/ 1	24	20	72	86.0	9,612	-148,886	13/ 1	24	20	72	87.5	9,612	-204,72
54	AC16 INT	3,278	13/ 1	24	20	72	86.0	1,130	-17,503	13/ 1	24	20	72	77.8	1,130	-23,67
Zone	54 Total/Ave.	3,278		24	20	72	86.0	1,130	-17,503		24	20	72	77.8	1,130	-23,67
Zone	54 Block	3,278	13/ 1	24	20	72	86.0	1,130	-17,503	13/ 1	24	20	72	77.8	1,130	-23,67
55	AC16 NOR	680	13/ 1	24	20	72	86.0	298	-4,616	13/ 1	24	20	72	79.6	298	-6,71
Zone	55 Total/Ave.	680		24	20	72	86.0	298	-4,616		24	20	72	79.6	298	-6,71
Zone	55 Block	680	13/ 1	24	20	72	86.0	298	-4,616	13/ 1	24	20	72	79.6	298	-6,71
56	AC16	8,368	13/ 1	24	20	72	86.0	2,187	-33,876	13/ 1	24	20	72	75.3	2,187	-39,57
Zone	56 Total/Ave.	8,368		24	20	72	86.0	2,187	-33,876		24	20	72	75.3	2,187	-39,57
Zone	56 Block	8,368	13/ 1	24	20	72	86.0	2,187	-33,876	13/ 1	24	20	72	75.3	2,187	-39,57
57	AC18	1,170	13/ 1	24	20	72	86.0	1,633	-25,294	13/ 1	24	20	72	87.2	1,633	-31,34
Zone	57 Total/Ave.	1,170		24	20	72	86.0	1,633	-25,294		24	20	72	87.2	1,633	-31,34
Zone	57 Block	1,170	13/ 1	24	20	72	86.0	1,633	-25,294	13/ 1	24	20	72	87.2	1,633	-31,34
System	8 Total/Ave.	26,965		24	20	72	86.0	20,562	-318,497		24	20	72	85.4	20,562	-416,54
System	8 Block	26,965	13/ 1	24	20	72	86.0	20,562	-318,496	13/ 1	24	20	72	85.4	20,562	-446,10

SYSTEM PSYCHROMETRICS - ALTERNATIVE 1
BASELINE MODEL

-------------- P S Y C H R O M E T R I C   S T A T E   P O I N T S --------------

System 1

	Dry Bulb (F)	Wet Bulb (F)	Relat. Humid. (%)	Humid. Ratio (GR)	Enthalpy (Btu/Lb)	Temp. Diff. (F)
Space	72.0	58.0	42.5	50.1	25.1	
Main System						
Return Air Heat Pickup						0.0
Return Fan						0.5
Return Air	72.5	58.2	41.8	50.1	25.2	
Outdoor Air	94.9	80.7	54.8	138.0	44.5	
Return/Outdoor Air Mix	94.9	80.7	54.8	138.0	44.5	
Blow through Fan						0.5
Entering Coil	95.4	80.9	54.0	138.0	44.7	
Leaving Coil	48.5	47.4	92.3	47.2	19.0	
Draw Through Fan						0.0
Duct Frictional Heat						1.6
Supply Duct Heat Gain						0.0
Cold Deck Supply Air	50.1	48.3	88.0	47.7	19.4	
Supply Air	53.5	49.8	77.6	47.7	20.2	

Percent Outside Air	100.00	(%)
Sensible Heat Ratio (SHR)	0.926	
Percent Supply Air Bypassing Coil	15.51	(%)
Coil Airflow	9,681	(Cfm)

SYSTEM PSYCHROMETRICS - ALTERNATIVE 1
BASELINE MODEL

-------------- P S Y C H R O M E T R I C S T A T E P O I N T S ---------------

System 2

	Dry Bulb (F)	Wet Bulb (F)	Relat. Humid. (%)	Humid. Ratio (GR)	Enthalpy (Btu/Lb)	Temp. Diff. (F)
Space	72.0	61.1	53.9	63.8	27.2	
Main System						
Return Air Heat Pickup						0.0
Return Fan						1.1
Return Air	73.1	61.5	52.0	63.8	27.5	
Outdoor Air	94.0	80.4	56.1	137.2	44.2	
Return/Outdoor Air Mix	94.0	80.4	56.1	137.2	44.2	
Blow through Fan						0.0
Entering Coil	94.0	80.4	56.1	137.2	44.2	
Leaving Coil	53.9	52.7	92.5	57.9	21.9	
Draw Through Fan						0.5
Duct Frictional Heat						1.6
Supply Duct Heat Gain						0.0
Cold Deck Supply Air	56.0	53.6	85.8	57.9	22.4	
Supply Air	56.0	53.6	85.8	57.9	22.4	

Percent Outside Air	100.00	(%)
Sensible Heat Ratio (SHR)	0.882	
Percent Supply Air Bypassing Coil	0.00	(%)
Coil Airflow	9,133	(Cfm)

SYSTEM PSYCHROMETRICS - ALTERNATIVE 1
BASELINE MODEL

-------------- P S Y C H R O M E T R I C   S T A T E   P O I N T S ---------------

System 3

	Dry Bulb (F)	Wet Bulb (F)	Relat. Humid. (%)	Humid. Ratio (GR)	Enthalpy (Btu/Lb)	Temp. Diff. (F)
Space	72.0	62.5	59.1	70.0	28.2	
Main System						
Return Air Heat Pickup						0.0
Return Fan						0.0
Return Air	72.0	62.5	59.1	70.0	28.2	
Outdoor Air	94.9	80.7	54.8	138.0	44.5	
Return/Outdoor Air Mix	78.9	68.8	60.4	90.4	33.1	
Blow through Fan						0.7
Entering Coil	79.6	69.0	59.0	90.4	33.3	
Leaving Coil	57.8	56.8	94.1	68.0	24.4	
Draw Through Fan						0.0
Duct Frictional Heat						2.2
Supply Duct Heat Gain						0.0
Cold Deck Supply Air	60.0	57.6	87.1	68.0	25.0	
Supply Air	60.0	57.6	87.1	68.0	25.0	

Percent Outside Air	29.98	(%)
Sensible Heat Ratio (SHR)	0.852	
Percent Supply Air Bypassing Coil	0.00	(%)
Coil Airflow	17,092	(Cfm)

SYSTEM PSYCHROMETRICS - ALTERNATIVE 1
BASELINE MODEL

------------- P S Y C H R O M E T R I C S T A T E P O I N T S --------------

System 4

	Dry Bulb (F)	Wet Bulb (F)	Relat. Humid. (%)	Humid. Ratio (GR)	Enthalpy (Btu/Lb)	Temp. Diff. (F)
Space	72.0	63.0	61.1	72.4	28.6	
Main System						
Return Air Heat Pickup						0.0
Return Fan						0.0
Return Air	72.0	63.0	61.1	72.4	28.6	
Outdoor Air	94.9	80.7	54.8	138.0	44.5	
Return/Outdoor Air Mix	78.4	68.7	61.6	90.8	33.0	
Blow through Fan						0.5
Entering Coil	79.0	68.9	60.5	90.8	33.2	
Leaving Coil	58.4	57.3	93.9	69.2	24.8	
Draw Through Fan						0.0
Duct Frictional Heat						1.6
Supply Duct Heat Gain						0.0
Cold Deck Supply Air	60.0	57.9	88.7	69.2	25.2	
Supply Air	60.0	57.9	88.7	69.2	25.2	

Percent Outside Air	28.14	(%)
Sensible Heat Ratio (SHR)	0.828	
Percent Supply Air Bypassing Coil	0.00	(%)
Coil Airflow	15,507	(Cfm)

SYSTEM PSYCHROMETRICS - ALTERNATIVE 1
BASELINE MODEL

-------------- P S Y C H R O M E T R I C   S T A T E   P O I N T S --------------

System 5

	Dry Bulb (F)	Wet Bulb (F)	Relat. Humid. (%)	Humid. Ratio (GR)	Enthalpy (Btu/Lb)	Temp. Diff. (F)
Space	72.0	59.8	49.1	58.0	26.3	
Main System						
Return Air Heat Pickup						-0.0
Return Fan						0.6
Return Air	72.6	60.1	48.1	58.0	26.5	
Outdoor Air	94.9	80.7	54.8	138.0	44.5	
Return/Outdoor Air Mix	74.7	62.4	50.5	65.5	28.2	
Blow through Fan						0.5
Entering Coil	75.2	62.6	49.7	65.5	28.3	
Leaving Coil	52.5	51.1	91.4	54.2	21.0	
Draw Through Fan						0.0
Duct Frictional Heat						1.6
Supply Duct Heat Gain						0.0
Cold Deck Supply Air	54.0	52.3	89.6	56.2	21.7	
Supply Air	57.8	53.9	78.1	56.2	22.6	

Percent Outside Air	9.36	(%)
Sensible Heat Ratio (SHR)	0.923	
Percent Supply Air Bypassing Coil	17.91	(%)
Coil Airflow	32,714	(Cfm)

SYSTEM PSYCHROMETRICS - ALTERNATIVE 1
BASELINE MODEL

-------------- P S Y C H R O M E T R I C   S T A T E   P O I N T S --------------

System 6

	Dry Bulb (F)	Wet Bulb (F)	Relat. Humid. (%)	Humid. Ratio (GR)	Enthalpy (Btu/Lb)	Temp. Diff. (F)
Space	72.0	63.0	61.3	72.6	28.6	
Main System						
Return Air Heat Pickup						-0.0
Return Fan						0.2
Return Air	72.2	63.1	60.8	72.6	28.7	
Outdoor Air	94.9	80.7	54.8	138.0	44.5	
Return/Outdoor Air Mix	89.3	77.0	57.8	122.0	40.6	
Blow through Fan						0.2
Entering Coil	89.5	77.1	57.4	122.0	40.7	
Leaving Coil	57.4	57.2	99.1	70.5	24.7	
Draw Through Fan						0.0
Duct Frictional Heat						0.6
Supply Duct Heat Gain						0.0
Cold Deck Supply Air	58.0	57.5	97.4	70.8	24.9	
Supply Air	58.0	57.5	97.4	70.8	24.9	

Percent Outside Air	75.45	(%)
Sensible Heat Ratio (SHR)	0.908	
Percent Supply Air Bypassing Coil	0.00	(%)
Coil Airflow	9,026	(Cfm)

SYSTEM PSYCHROMETRICS - ALTERNATIVE 1
BASELINE MODEL

-------------- P S Y C H R O M E T R I C   S T A T E   P O I N T S --------------

System 7

	Dry Bulb (F)	Wet Bulb (F)	Relat. Humid. (%)	Humid. Ratio (GR)	Enthalpy (Btu/Lb)	Temp. Diff. (F)
Space	72.0	59.9	49.5	58.4	26.4	
Main System						
Return Air Heat Pickup						0.0
Return Fan						0.7
Return Air	72.7	60.2	48.3	58.4	26.6	
Outdoor Air	94.9	80.7	54.8	138.0	44.5	
Return/Outdoor Air Mix	78.3	66.3	53.5	78.3	31.0	
Blow through Fan						1.1
Entering Coil	79.4	66.6	51.6	78.3	31.3	
Leaving Coil	52.7	51.9	94.8	56.7	21.4	
Draw Through Fan						0.0
Duct Frictional Heat						3.3
Supply Duct Heat Gain						0.0
Cold Deck Supply Air	56.0	53.6	85.7	57.8	22.4	
Supply Air	57.3	54.1	81.9	57.8	22.7	

Percent Outside Air	24.95	(%)
Sensible Heat Ratio (SHR)	0.954	
Percent Supply Air Bypassing Coil	5.41	(%)
Coil Airflow	38,626	(Cfm)

SYSTEM PSYCHROMETRICS - ALTERNATIVE 1
BASELINE MODEL

-------------- P S Y C H R O M E T R I C   S T A T E   P O I N T S ---------------

System 8

	Dry Bulb (F)	Wet Bulb (F)	Relat. Humid. (%)	Humid. Ratio (GR)	Enthalpy (Btu/Lb)	Temp. Diff. (F)
Space	72.0	61.6	55.9	66.1	27.6	
Main System						
Return Air Heat Pickup						-0.0
Return Fan						0.4
Return Air	72.4	61.8	55.2	66.1	27.7	
Outdoor Air	94.9	80.7	54.8	138.0	44.5	
Return/Outdoor Air Mix	76.6	65.9	57.5	79.4	30.8	
Blow through Fan						0.7
Entering Coil	77.2	66.1	56.2	79.4	31.0	
Leaving Coil	56.9	55.6	92.6	64.7	23.7	
Draw Through Fan						0.0
Duct Frictional Heat						2.0
Supply Duct Heat Gain						0.0
Cold Deck Supply Air	58.9	56.5	86.4	64.8	24.2	
Supply Air	60.0	56.9	83.1	64.8	24.5	

Percent Outside Air	18.52	(%)
Sensible Heat Ratio (SHR)	0.922	
Percent Supply Air Bypassing Coil	8.25	(%)
Coil Airflow	18,866	(Cfm)

AUXILIARY PSYCHROMETRICS - ALTERNATIVE 1
BASELINE MODEL

-------------- P S Y C H R O M E T R I C   S T A T E   P O I N T S ---------------

Room 11

	Dry Bulb (F)	Wet Bulb (F)	Relat. Humid. (%)	Humid. Ratio (GR)	Enthalpy (Btu/Lb)	Temp. Diff. (F)
Space	72.0	60.0	49.8	58.9	26.5	
Auxiliary System						
Blow through Fan						0.1
Entering Coil	72.1	60.1	49.6	58.9	26.5	
Leaving Coil	55.8	53.7	87.8	58.9	22.5	
Draw Through Fan						0.0
Duct Frictional Heat						0.2
Supply Air	56.0	53.8	87.2	58.9	22.6	

Sensible Heat Ratio (SHR) 1.000
Coil Airflow 992 (Cfm)

****
* THE PSYCHROMETRIC LOOP DID NOT CLOSE *
* SUPPLY AIR TEMPERATURE RESET *
****

-------------- P S Y C H R O M E T R I C   S T A T E   P O I N T S ---------------

Room 12

	Dry Bulb (F)	Wet Bulb (F)	Relat. Humid. (%)	Humid. Ratio (GR)	Enthalpy (Btu/Lb)	Temp. Diff. (F)
Space	72.0	60.0	49.8	58.9	26.5	
Auxiliary System						
Blow through Fan						0.1
Entering Coil	72.1	60.1	49.6	58.9	26.5	
Leaving Coil	55.8	53.7	87.8	58.9	22.5	
Draw Through Fan						0.0
Duct Frictional Heat						0.2
Supply Air	56.0	53.8	87.2	58.9	22.6	

Sensible Heat Ratio (SHR) 1.000
Coil Airflow 381 (Cfm)

****
* THE PSYCHROMETRIC LOOP DID NOT CLOSE *
* SUPPLY AIR TEMPERATURE RESET *
****

AUXILIARY PSYCHROMETRICS - ALTERNATIVE 1
BASELINE MODEL

-------------- P S Y C H R O M E T R I C   S T A T E   P O I N T S --------------

Room 13

	Dry Bulb (F)	Wet Bulb (F)	Relat. Humid. (%)	Humid. Ratio (GR)	Enthalpy (Btu/Lb)	Temp. Diff. (F)
Space	72.0	60.0	49.8	58.9	26.5	
Auxiliary System						
Blow through Fan						0.1
Entering Coil	72.1	60.1	49.6	58.9	26.5	
Leaving Coil	55.8	53.7	87.8	58.9	22.5	
Draw Through Fan						0.0
Duct Frictional Heat						0.2
Supply Air	56.0	53.8	87.2	58.9	22.6	

Sensible Heat Ratio (SHR) 1.000
Coil Airflow 2,764 (Cfm)

****
* THE PSYCHROMETRIC LOOP DID NOT CLOSE *
* SUPPLY AIR TEMPERATURE RESET *
****

-------------- P S Y C H R O M E T R I C   S T A T E   P O I N T S --------------

Room 14

	Dry Bulb (F)	Wet Bulb (F)	Relat. Humid. (%)	Humid. Ratio (GR)	Enthalpy (Btu/Lb)	Temp. Diff. (F)
Space	72.0	60.0	49.8	58.9	26.5	
Auxiliary System						
Blow through Fan						0.1
Entering Coil	72.1	60.1	49.6	58.9	26.5	
Leaving Coil	55.8	53.7	87.8	58.9	22.5	
Draw Through Fan						0.0
Duct Frictional Heat						0.2
Supply Air	56.0	53.8	87.2	58.9	22.6	

Sensible Heat Ratio (SHR) 1.000
Coil Airflow 2,918 (Cfm)

****
* THE PSYCHROMETRIC LOOP DID NOT CLOSE *
* SUPPLY AIR TEMPERATURE RESET *
****

AUXILIARY PSYCHROMETRICS - ALTERNATIVE 1
BASELINE MODEL

-------------- P S Y C H R O M E T R I C   S T A T E   P O I N T S ---------------

Room 15

	Dry Bulb (F)	Wet Bulb (F)	Relat. Humid. (%)	Humid. Ratio (GR)	Enthalpy (Btu/Lb)	Temp. Diff. (F)
Space	72.0	60.0	49.8	58.9	26.5	
Auxiliary System						
Blow through Fan						0.1
Entering Coil	72.1	60.1	49.6	58.9	26.5	
Leaving Coil	55.8	53.7	87.8	58.9	22.5	
Draw Through Fan						0.0
Duct Frictional Heat						0.2
Supply Air	56.0	53.8	87.2	58.9	22.6	

Sensible Heat Ratio (SHR) 1.000
Coil Airflow 203 (Cfm)

```
******************************************
* THE PSYCHROMETRIC LOOP DID NOT CLOSE *
* SUPPLY AIR TEMPERATURE RESET         *
******************************************
```

BUILDING U-VALUES - ALTERNATIVE 1
BASELINE MODEL

---------------------------------- B U I L D I N G   U - V A L U E S ----------------------------------

Room Number	Description	Part.	ExFlr	Summr Skylt	Wintr Skylt	Roof	Summr Windo	Wintr Windo	Wall	Ceil.	Room Mass (lb/ sqft)	Room Capac. (Btu/ sqft/F)
		Room U-Values (Btu/hr/sqft/F)										
1	SURGERY1	0.000	0.000	0.000	0.000	0.100	0.000	0.000	0.250	0.000	148.0	29.95
Zone	1 Total/Ave.	0.000	0.000	0.000	0.000	0.100	0.000	0.000	0.250	0.000	148.0	29.95
2	SUR CORR	0.000	0.000	0.000	0.000	0.100	0.000	0.000	0.250	0.000	51.1	10.81
Zone	2 Total/Ave.	0.000	0.000	0.000	0.000	0.100	0.000	0.000	0.250	0.000	51.1	10.81
3	SURGERY2	0.000	0.000	0.000	0.000	0.100	0.000	0.000	0.000	0.000	20.9	4.83
Zone	3 Total/Ave.	0.000	0.000	0.000	0.000	0.100	0.000	0.000	0.000	0.000	20.9	4.83
4	DEL 1	0.000	0.000	0.000	0.000	0.100	0.000	0.000	0.250	0.000	179.7	36.23
Zone	4 Total/Ave.	0.000	0.000	0.000	0.000	0.100	0.000	0.000	0.250	0.000	179.7	36.23
5	DEL 2	0.000	0.000	0.000	0.000	0.100	0.000	0.000	0.250	0.000	84.4	17.39
Zone	5 Total/Ave.	0.000	0.000	0.000	0.000	0.100	0.000	0.000	0.250	0.000	84.4	17.39
6	LABOR	0.000	0.000	0.000	0.000	0.250	0.000	0.000	0.000	0.000	20.9	4.83
Zone	6 Total/Ave.	0.000	0.000	0.000	0.000	0.250	0.000	0.000	0.000	0.000	20.9	4.83
7	SUR. LOUN	0.000	0.000	0.000	0.000	0.100	0.000	0.000	0.100	0.000	48.0	10.19
Zone	7 Total/Ave.	0.000	0.000	0.000	0.000	0.100	0.000	0.000	0.100	0.000	48.0	10.19
8	NURSERY	0.000	0.000	0.000	0.000	0.100	0.000	0.000	0.000	0.000	20.9	4.83
Zone	8 Total/Ave.	0.000	0.000	0.000	0.000	0.100	0.000	0.000	0.000	0.000	20.9	4.83
9	OB RECOV	0.000	0.000	0.000	0.000	0.100	0.000	0.000	0.250	0.000	84.4	17.39
Zone	9 Total/Ave.	0.000	0.000	0.000	0.000	0.100	0.000	0.000	0.250	0.000	84.4	17.39
10	OR RECOV	0.000	0.000	0.000	0.000	0.100	0.000	0.000	0.000	0.000	20.9	4.83
Zone	10 Total/Ave.	0.000	0.000	0.000	0.000	0.100	0.000	0.000	0.000	0.000	20.9	4.83
System	1 Total/Ave.	0.000	0.000	0.000	0.000	0.134	0.000	0.000	0.213	0.000	49.8	10.54
11	PERIM N.	0.000	0.000	0.000	0.000	0.100	1.130	1.247	0.250	0.000	62.9	13.13
Zone	11 Total/Ave.	0.000	0.000	0.000	0.000	0.100	1.130	1.247	0.250	0.000	62.9	13.13
12	PERIM. S	0.000	0.000	0.000	0.000	0.100	1.130	1.247	0.250	0.000	79.8	16.47
Zone	12 Total/Ave.	0.000	0.000	0.000	0.000	0.100	1.130	1.247	0.250	0.000	79.8	16.47
13	INT. N	0.000	0.000	0.000	0.000	0.100	0.000	0.000	0.000	0.000	20.9	4.83
Zone	13 Total/Ave.	0.000	0.000	0.000	0.000	0.100	0.000	0.000	0.000	0.000	20.9	4.83
14	INT. S	0.000	0.000	0.000	0.000	0.100	0.000	0.000	0.000	0.000	20.9	4.83
Zone	14 Total/Ave.	0.000	0.000	0.000	0.000	0.100	0.000	0.000	0.000	0.000	20.9	4.83
15	ICU	0.000	0.000	0.000	0.000	0.100	1.130	1.247	0.250	0.000	73.6	15.26
Zone	15 Total/Ave.	0.000	0.000	0.000	0.000	0.100	1.130	1.247	0.250	0.000	73.6	15.26
System	2 Total/Ave.	0.000	0.000	0.000	0.000	0.100	1.130	1.247	0.250	0.000	40.9	8.78
16	KIT ADMIN	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.317	13.3	2.67
Zone	16 Total/Ave.	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.317	13.3	2.67
17	FOOD PRE	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.150	0.317	20.6	4.11
Zone	17 Total/Ave.	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.150	0.317	20.6	4.11
18	XRAY EXT	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.317	13.3	2.67
Zone	18 Total/Ave.	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.317	13.3	2.67
19	XRAY INT	0.000	0.000	0.000	0.000	0.050	0.000	0.000	0.150	0.317	76.5	15.82
Zone	19 Total/Ave.	0.000	0.000	0.000	0.000	0.050	0.000	0.000	0.150	0.317	76.5	15.82
20	PHY THER	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.317	13.3	2.67
Zone	20 Total/Ave.	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.317	13.3	2.67
21	ADMIN	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.317	13.3	2.67
Zone	21 Total/Ave.	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.317	13.3	2.67
22	SUR.CLINIC	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.317	13.3	2.67

Zone	22	Total/Ave.	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.317	13.3	2.67
	23	SUR.CLINIC	0.000	0.000	0.000	0.000	0.050	0.000	0.000	0.000	0.317	20.9	4.83
Zone	23	Total/Ave.	0.000	0.000	0.000	0.000	0.050	0.000	0.000	0.000	0.317	20.9	4.83

BUILDING U-VALUES - ALTERNATIVE 1
BASELINE MODEL

---------------------------------- B U I L D I N G   U - V A L U E S ----------------------------------

Room Number	Description	Part.	ExFlr	Summr Skylt	Wintr Skylt	Roof	Summr Windo	Wintr Windo	Wall	Ceil.	Room Mass (lb/ sqft)	Room Capac. (Btu/ sqft/F)
		Room U-Values (Btu/hr/sqft/F)										
24	MECH	0.000	0.000	0.000	0.000	0.050	0.000	0.000	0.000	0.317	16.9	3.68
Zone	24 Total/Ave.	0.000	0.000	0.000	0.000	0.050	0.000	0.000	0.000	0.317	16.9	3.68
25	E.R.AC10	0.000	0.000	0.000	0.000	0.050	1.130	1.247	0.250	0.317	33.3	7.29
Zone	25 Total/Ave.	0.000	0.000	0.000	0.000	0.050	1.130	1.247	0.250	0.317	33.3	7.29
System	3 Total/Ave.	0.000	0.000	0.000	0.000	0.050	1.130	1.247	0.175	0.317	22.7	4.80
26	ADMIN	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.317	13.3	2.67
Zone	26 Total/Ave.	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.317	13.3	2.67
27	DENT EXT	0.000	0.000	0.000	0.000	0.050	1.170	1.296	0.250	0.317	105.4	21.21
Zone	27 Total/Ave.	0.000	0.000	0.000	0.000	0.050	1.170	1.296	0.250	0.317	105.4	21.21
28	DENT INT	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.317	13.3	2.67
Zone	28 Total/Ave.	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.317	13.3	2.67
29	EENT EXT	0.000	0.000	0.000	0.000	0.050	0.000	0.000	0.150	0.317	95.0	19.49
Zone	29 Total/Ave.	0.000	0.000	0.000	0.000	0.050	0.000	0.000	0.150	0.317	95.0	19.49
30	EENT INT	0.000	0.000	0.000	0.000	0.050	0.000	0.000	0.000	0.317	20.9	4.83
Zone	30 Total/Ave.	0.000	0.000	0.000	0.000	0.050	0.000	0.000	0.000	0.317	20.9	4.83
31	AREA S	0.000	0.000	0.000	0.000	0.050	0.000	0.000	0.000	0.317	20.9	4.83
Zone	31 Total/Ave.	0.000	0.000	0.000	0.000	0.050	0.000	0.000	0.000	0.317	20.9	4.83
32	DINING	0.000	0.000	0.000	0.000	0.000	1.170	1.296	0.250	0.317	31.0	6.16
Zone	32 Total/Ave.	0.000	0.000	0.000	0.000	0.000	1.170	1.296	0.250	0.317	31.0	6.16
System	4 Total/Ave.	0.000	0.000	0.000	0.000	0.050	1.170	1.296	0.205	0.317	29.0	6.07
33	AC8 NORT	0.000	0.000	0.000	0.000	0.150	0.490	0.511	0.150	0.317	120.3	24.82
Zone	33 Total/Ave.	0.000	0.000	0.000	0.000	0.150	0.490	0.511	0.150	0.317	120.3	24.82
34	AC8 EAST	0.000	0.000	0.000	0.000	0.150	0.490	0.511	0.150	0.317	161.1	32.88
Zone	34 Total/Ave.	0.000	0.000	0.000	0.000	0.150	0.490	0.511	0.150	0.317	161.1	32.88
35	AC7 SO	0.000	0.000	0.000	0.000	0.150	0.490	0.511	0.150	0.317	88.7	18.59
Zone	35 Total/Ave.	0.000	0.000	0.000	0.000	0.150	0.490	0.511	0.150	0.317	88.7	18.59
36	AC8 SO	0.000	0.000	0.000	0.000	0.150	0.490	0.511	0.150	0.317	148.9	30.49
Zone	36 Total/Ave.	0.000	0.000	0.000	0.000	0.150	0.490	0.511	0.150	0.317	148.9	30.49
37	AC7 WEST	0.000	0.000	0.000	0.000	0.150	0.490	0.511	0.150	0.317	173.6	35.36
Zone	37 Total/Ave.	0.000	0.000	0.000	0.000	0.150	0.490	0.511	0.150	0.317	173.6	35.36
38	AC7 INT	0.000	0.000	0.000	0.000	0.150	0.000	0.000	0.000	0.317	64.8	13.86
Zone	38 Total/Ave.	0.000	0.000	0.000	0.000	0.150	0.000	0.000	0.000	0.317	64.8	13.86
39	AC8 INT	0.000	0.000	0.000	0.000	0.150	0.000	0.000	0.000	0.317	64.8	13.86
Zone	39 Total/Ave.	0.000	0.000	0.000	0.000	0.150	0.000	0.000	0.000	0.317	64.8	13.86
System	5 Total/Ave.	0.000	0.000	0.000	0.000	0.150	0.490	0.511	0.150	0.317	84.4	17.73
40	AC9 LAB	0.000	0.000	0.000	0.000	0.150	0.000	0.000	0.150	0.317	71.1	15.10
Zone	40 Total/Ave.	0.000	0.000	0.000	0.000	0.150	0.000	0.000	0.150	0.317	71.1	15.10
System	6 Total/Ave.	0.000	0.000	0.000	0.000	0.150	0.000	0.000	0.150	0.317	71.1	15.10
41	WEST CMS	0.000	0.000	0.000	0.000	0.150	0.000	0.000	0.150	0.317	84.3	17.71
Zone	41 Total/Ave.	0.000	0.000	0.000	0.000	0.150	0.000	0.000	0.150	0.317	84.3	17.71
42	AC11 WES	0.000	0.000	0.000	0.000	0.150	0.490	0.511	0.150	0.317	88.9	18.62
Zone	42 Total/Ave.	0.000	0.000	0.000	0.000	0.150	0.490	0.511	0.150	0.317	88.9	18.62
43	AC14 WES	0.000	0.000	0.000	0.000	0.150	0.490	0.511	0.150	0.317	132.2	27.17
Zone	43 Total/Ave.	0.000	0.000	0.000	0.000	0.150	0.490	0.511	0.150	0.317	132.2	27.17
44	AC13 SOU	0.000	0.000	0.000	0.000	0.150	0.490	0.511	0.150	0.317	121.3	25.02

Zone	44	Total/Ave.	0.000	0.000	0.000	0.000	0.150	0.490	0.511	0.150	0.317	121.3	25.02
	45	AC11 EAS	0.000	0.000	0.000	0.000	0.150	0.490	0.511	0.150	0.317	92.1	19.26
Zone	45	Total/Ave.	0.000	0.000	0.000	0.000	0.150	0.490	0.511	0.150	0.317	92.1	19.26

BUILDING U-VALUES - ALTERNATIVE 1
BASELINE MODEL

---------------------------------- B U I L D I N G   U - V A L U E S ----------------------------------

Room Number	Description	Part.	ExFlr	Summr Skylt	Wintr Skylt	Roof	Summr Windo	Wintr Windo	Wall	Ceil.	Room Mass (lb/ sqft)	Room Capac. (Btu/ sqft/F)
		Room U-Values (Btu/hr/sqft/F)										
46	AC14 EAS	0.000	0.000	0.000	0.000	0.150	0.490	0.511	0.150	0.317	78.3	16.53
Zone	46 Total/Ave.	0.000	0.000	0.000	0.000	0.150	0.490	0.511	0.150	0.317	78.3	16.53
47	AC13 EAS	0.000	0.000	0.000	0.000	0.150	0.000	0.000	0.150	0.317	102.9	21.38
Zone	47 Total/Ave.	0.000	0.000	0.000	0.000	0.150	0.000	0.000	0.150	0.317	102.9	21.38
48	AC11 INT	0.000	0.000	0.000	0.000	0.150	0.000	0.000	0.000	0.317	64.8	13.86
Zone	48 Total/Ave.	0.000	0.000	0.000	0.000	0.150	0.000	0.000	0.000	0.317	64.8	13.86
49	AC14 INT	0.000	0.000	0.000	0.000	0.150	0.000	0.000	0.000	0.317	64.8	13.86
Zone	49 Total/Ave.	0.000	0.000	0.000	0.000	0.150	0.000	0.000	0.000	0.317	64.8	13.86
50	AC13 INT	0.000	0.000	0.000	0.000	0.150	0.000	0.000	0.000	0.317	64.8	13.86
Zone	50 Total/Ave.	0.000	0.000	0.000	0.000	0.150	0.000	0.000	0.000	0.317	64.8	13.86
System	7 Total/Ave.	0.000	0.000	0.000	0.000	0.150	0.490	0.511	0.150	0.317	82.2	17.29
51	AC17 WES	0.000	0.000	0.000	0.000	0.150	0.490	0.511	0.150	0.317	106.6	22.12
Zone	51 Total/Ave.	0.000	0.000	0.000	0.000	0.150	0.490	0.511	0.150	0.317	106.6	22.12
52	AC17 NOR	0.000	0.000	0.000	0.000	0.150	0.490	0.511	0.150	0.317	125.0	25.76
Zone	52 Total/Ave.	0.000	0.000	0.000	0.000	0.150	0.490	0.511	0.150	0.317	125.0	25.76
53	AC17 INT	0.000	0.000	0.000	0.000	0.150	0.000	0.000	0.000	0.317	64.8	13.86
Zone	53 Total/Ave.	0.000	0.000	0.000	0.000	0.150	0.000	0.000	0.000	0.317	64.8	13.86
54	AC16 INT	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.317	13.3	2.67
Zone	54 Total/Ave.	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.317	13.3	2.67
55	AC16 NOR	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.150	0.317	91.6	18.13
Zone	55 Total/Ave.	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.150	0.317	91.6	18.13
56	AC16	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.317	13.3	2.67
Zone	56 Total/Ave.	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.317	13.3	2.67
57	AC18	0.000	0.000	0.000	0.000	0.150	0.000	0.000	0.150	0.317	117.3	24.23
Zone	57 Total/Ave.	0.000	0.000	0.000	0.000	0.150	0.000	0.000	0.150	0.317	117.3	24.23
System	8 Total/Ave.	0.000	0.000	0.000	0.000	0.150	0.490	0.511	0.150	0.317	54.6	11.38
Building		0.000	0.000	0.000	0.000	0.130	0.770	0.833	0.172	0.317	58.8	12.38

BUILDING AREAS - ALTERNATIVE 1
BASELINE MODEL

--- B U I L D I N G   A R E A S ---

Room Number	Description	Number of Duplicate Flr	Rm	Floor Area/Dupl Room (sqft)	Total Floor Area (sqft)	Partition Area (sqft)	Exposed Floor Area (sqft)	Skylight Area (sqft)	Skl /Rf (%)	Net Roof Area (sqft)	Window Area (sqft)	Win /Wl (%)	Net Wall Area (sqft)
1	SURGERY1	1	1	441	441	0	0	0	0	441	0	0	546
Zone	1 Total/Ave.				441	0	0	0	0	441	0	0	546
2	SUR CORR	1	1	927	927	0	0	0	0	927	0	0	273
Zone	2 Total/Ave.				927	0	0	0	0	927	0	0	273
3	SURGERY2	1	1	400	400	0	0	0	0	400	0	0	0
Zone	3 Total/Ave.				400	0	0	0	0	400	0	0	0
4	DEL 1	1	1	294	294	0	0	0	0	294	0	0	455
Zone	4 Total/Ave.				294	0	0	0	0	294	0	0	455
5	DEL 2	1	1	273	273	0	0	0	0	273	0	0	169
Zone	5 Total/Ave.				273	0	0	0	0	273	0	0	169
6	LABOR	1	1	1,695	1,695	0	0	0	0	1,695	0	0	0
Zone	6 Total/Ave.				1,695	0	0	0	0	1,695	0	0	0
7	SUR. LOUN	1	1	1,968	1,968	0	0	0	0	1,968	0	0	520
Zone	7 Total/Ave.				1,968	0	0	0	0	1,968	0	0	520
8	NURSERY	1	1	879	879	0	0	0	0	879	0	0	0
Zone	8 Total/Ave.				879	0	0	0	0	879	0	0	0
9	OB RECOV	1	1	252	252	0	0	0	0	252	0	0	156
Zone	9 Total/Ave.				252	0	0	0	0	252	0	0	156
10	OR RECOV	1	1	405	405	0	0	0	0	405	0	0	0
Zone	10 Total/Ave.				405	0	0	0	0	405	0	0	0
System	1 Total/Ave.				7,534	0	0	0	0	7,534	0	0	2,119
11	PERIM N.	1	1	4,644	4,644	0	0	0	0	4,644	389	17	1,899
Zone	11 Total/Ave.				4,644	0	0	0	0	4,644	389	17	1,899
12	PERIM. S	1	1	1,980	1,980	0	0	0	0	1,980	60	5	1,136
Zone	12 Total/Ave.				1,980	0	0	0	0	1,980	60	5	1,136
13	INT. N	1	1	4,968	4,968	0	0	0	0	4,968	0	0	[illegible]
Zone	13 Total/Ave.				4,968	0	0	0	0	4,968	0	0	[illegible]
14	INT. S	1	1	5,244	5,244	0	0	0	0	5,244	0	0	[illegible]
Zone	14 Total/Ave.				5,244	0	0	0	0	5,244	0	0	[illegible]
15	ICU	1	1	756	756	0	0	0	0	756	80	17	38[illegible]
Zone	15 Total/Ave.				756	0	0	0	0	756	80	17	38[illegible]
System	2 Total/Ave.				17,592	0	0	0	0	17,592	528	13	3,42[illegible]
16	KIT ADMIN	1	1	1,032	1,032	0	0	0	0	0	0	0	[illegible]
Zone	16 Total/Ave.				1,032	0	0	0	0	0	0	0	[illegible]
17	FOOD PRE	1	1	1,828	1,828	0	0	0	0	0	0	0	13[illegible]
Zone	17 Total/Ave.				1,828	0	0	0	0	0	0	0	13[illegible]
18	XRAY EXT	1	1	5,336	5,336	0	0	0	0	0	0	0	[illegible]
Zone	18 Total/Ave.				5,336	0	0	0	0	0	0	0	[illegible]
19	XRAY INT	1	1	2,352	2,352	0	0	0	0	2,352	0	0	1,27[illegible]
Zone	19 Total/Ave.				2,352	0	0	0	0	2,352	0	0	1,27[illegible]
20	PHY THER	1	1	4,404	4,404	0	0	0	0	0	0	0	[illegible]
Zone	20 Total/Ave.				4,404	0	0	0	0	0	0	0	[illegible]
21	ADMIN	1	1	1,790	1,790	0	0	0	0	0	0	0	[illegible]
Zone	21 Total/Ave.				1,790	0	0	0	0	0	0	0	[illegible]
22	SUR.CLINIC	1	1	3,116	3,116	0	0	0	0	0	0	0	[illegible]

Zone	22	Total/Ave.				3,116	0	0	0	0	0	0	0
	23	SUR.CLINIC	1	1	5,822	5,822	0	0	0	0	5,822	0	0
Zone	23	Total/Ave.				5,822	0	0	0	0	5,822	0	0

BUILDING AREAS - ALTERNATIVE 1
BASELINE MODEL

-- B U I L D I N G   A R E A S --

Room Number	Description	Number of Duplicate Flr	Number of Duplicate Rm	Floor Area/Dupl Room (sqft)	Total Floor Area (sqft)	Partition Area (sqft)	Exposed Floor Area (sqft)	Skylight Area (sqft)	Skl /Rf (%)	Net Roof Area (sqft)	Window Area (sqft)	Win /Wl (%)	Net Wall Area (sqft)
24	MECH	1	1	1,072	1,072	0	0	0	0	500	0	0	0
Zone	24 Total/Ave.				1,072	0	0	0	0	500	0	0	0
25	E.R.AC10	1	1	3,915	3,915	0	0	0	0	3,915	118	20	47
Zone	25 Total/Ave.				3,915	0	0	0	0	3,915	118	20	47
System	3 Total/Ave.				30,667	0	0	0	0	12,589	118	6	1,87
26	ADMIN	1	1	2,964	2,964	0	0	0	0	0	0	0	0
Zone	26 Total/Ave.				2,964	0	0	0	0	0	0	0	0
27	DENT EXT	1	1	1,210	1,210	0	0	0	0	605	116	10	1,04
Zone	27 Total/Ave.				1,210	0	0	0	0	605	116	10	1,04
28	DENT INT	1	1	5,899	5,899	0	0	0	0	0	0	0	0
Zone	28 Total/Ave.				5,899	0	0	0	0	0	0	0	0
29	EENT EXT	1	1	1,512	1,512	0	0	0	0	1,512	0	0	1,09
Zone	29 Total/Ave.				1,512	0	0	0	0	1,512	0	0	1,09
30	EENT INT	1	1	3,696	3,696	0	0	0	0	3,696	0	0	
Zone	30 Total/Ave.				3,696	0	0	0	0	3,696	0	0	
31	AREA S	1	1	3,240	3,240	0	0	0	0	3,240	0	0	
Zone	31 Total/Ave.				3,240	0	0	0	0	3,240	0	0	
32	DINING	1	1	1,734	1,734	0	0	0	0	0	365	55	29
Zone	32 Total/Ave.				1,734	0	0	0	0	0	365	55	29
System	4 Total/Ave.				20,255	0	0	0	0	9,053	480	16	2,43
33	AC8 NORT	1	1	1,579	1,579	0	0	0	0	1,579	106	11	85
Zone	33 Total/Ave.				1,579	0	0	0	0	1,579	106	11	85
34	AC8 EAST	1	1	2,367	2,367	0	0	0	0	2,367	194	8	2,22
Zone	34 Total/Ave.				2,367	0	0	0	0	2,367	194	8	2,22
35	AC7 SO	1	1	4,967	4,967	0	0	0	0	4,967	255	18	1,16
Zone	35 Total/Ave.				4,967	0	0	0	0	4,967	255	18	1,16
36	AC8 SO	1	1	2,268	2,268	0	0	0	0	2,268	254	12	1,86
Zone	36 Total/Ave.				2,268	0	0	0	0	2,268	254	12	1,86
37	AC7 WEST	1	1	1,772	1,772	0	0	0	0	1,772	209	10	1,88
Zone	37 Total/Ave.				1,772	0	0	0	0	1,772	209	10	1,88
38	AC7 INT	1	1	13,657	13,657	0	0	0	0	13,657	0	0	
Zone	38 Total/Ave.				13,657	0	0	0	0	13,657	0	0	
39	AC8 INT	1	1	15,184	15,184	0	0	0	0	15,184	0	0	
Zone	39 Total/Ave.				15,184	0	0	0	0	15,184	0	0	
System	5 Total/Ave.				41,794	0	0	0	0	41,794	1,018	11	7,9
40	AC9 LAB	1	1	8,039	8,039	0	0	0	0	8,039	0	0	4
Zone	40 Total/Ave.				8,039	0	0	0	0	8,039	0	0	4
System	6 Total/Ave.				8,039	0	0	0	0	8,039	0	0	4
41	WEST CHS	1	1	4,776	4,776	0	0	0	0	4,776	0	0	9
Zone	41 Total/Ave.				4,776	0	0	0	0	4,776	0	0	9
42	AC11 WES	1	1	3,671	3,671	0	0	0	0	3,671	46	5	8
Zone	42 Total/Ave.				3,671	0	0	0	0	3,671	46	5	8
43	AC14 WES	1	1	1,763	1,763	0	0	0	0	1,763	61	5	1,1
Zone	43 Total/Ave.				1,763	0	0	0	0	1,763	61	5	1,1
44	AC13 SOU	1	1	1,798	1,798	0	0	0	0	1,798	86	8	9

Zone		44	Total/Ave.				1,798	0	0	0	0	1,798	86	8	99[illegible]
	45	AC11	EAS	1	1	3,067	3,067	0	0	0	0	3,067	91	10	81[illegible]
Zone		45	Total/Ave.				3,067	0	0	0	0	3,067	91	10	81[illegible]

BUILDING AREAS - ALTERNATIVE 1
BASELINE MODEL

B U I L D I N G   A R E A S

Room Number	Description	Number of Duplicate Flr	Rm	Floor Area/Dupl Room (sqft)	Total Floor Area (sqft)	Partition Area (sqft)	Exposed Floor Area (sqft)	Skylight Area (sqft)	Skl /Rf (%)	Net Roof Area (sqft)	Window Area (sqft)	Win /Wl (%)	Net Wall Area (sqft)
46	AC14 EAS	1	1	6,380	6,380	0	0	0	0	6,380	94	10	842
Zone	46 Total/Ave.				6,380	0	0	0	0	6,380	94	10	842
47	AC13 EAS	1	1	5,310	5,310	0	0	0	0	5,310	0	0	1,976
Zone	47 Total/Ave.				5,310	0	0	0	0	5,310	0	0	1,976
48	AC11 INT	1	1	4,485	4,485	0	0	0	0	4,485	0	0	0
Zone	48 Total/Ave.				4,485	0	0	0	0	4,485	0	0	0
49	AC14 INT	1	1	5,828	5,828	0	0	0	0	5,828	0	0	0
Zone	49 Total/Ave.				5,828	0	0	0	0	5,828	0	0	0
50	AC13 INT	1	1	7,562	7,562	0	0	0	0	7,562	0	0	0
Zone	50 Total/Ave.				7,562	0	0	0	0	7,562	0	0	0
System	7 Total/Ave.				44,640	0	0	0	0	44,640	378	5	7,56
51	AC17 WES	1	1	1,119	1,119	0	0	0	0	1,119	24	5	45
Zone	51 Total/Ave.				1,119	0	0	0	0	1,119	24	5	45
52	AC17 NOR	1	1	3,295	3,295	0	0	0	0	3,295	102	5	1,93
Zone	52 Total/Ave.				3,295	0	0	0	0	3,295	102	5	1,93
53	AC17 INT	1	1	9,055	9,055	0	0	0	0	9,055	0	0	
Zone	53 Total/Ave.				9,055	0	0	0	0	9,055	0	0	
54	AC16 INT	1	1	3,278	3,278	0	0	0	0	0	0	0	
Zone	54 Total/Ave.				3,278	0	0	0	0	0	0	0	
55	AC16 NOR	1	1	680	680	0	0	0	0	0	0	0	52
Zone	55 Total/Ave.				680	0	0	0	0	0	0	0	52
56	AC16	1	1	8,368	8,368	0	0	0	0	0	0	0	
Zone	56 Total/Ave.				8,368	0	0	0	0	0	0	0	
57	AC18	1	1	1,170	1,170	0	0	0	0	1,170	0	0	60
Zone	57 Total/Ave.				1,170	0	0	0	0	1,170	0	0	60
System	8 Total/Ave.				26,965	0	0	0	0	14,639	126	3	3,51
Building					197,486	0	0	0	0	155,880	2,649	8	29,42

ASHRAE 90 ANALYSIS - ALTERNATIVE 1
BASELINE MODEL

--------------- A S H R A E   9 0   A N A L Y S I S ---------------

Overall Roof U-Value = 0.130 (Btu/Hr/Sq Ft/F)
Overall Wall U-Value = 0.222 (Btu/Hr/Sq Ft/F)
Overall Building U-Value = 0.145 (Btu/Hr/Sq Ft/F)

Roof Overall Thermal Transfer Value (OTTVr) = 7.33 (Btu/Hr/Sq Ft)
Wall Overall Thermal Transfer Value (OTTVw) = 11.39 (Btu/Hr/Sq Ft)

Trane Air Conditioning Economics
By: ENGINEERING RESOURCE GROUP, INC.

SYSTEM LOAD PROFILE - ALTERNATIVE 1
BASELINE MODEL

Main System 1 BPMZ BYPASS MULTIZONE

Percent Design Load	Cooling Load Cap. (Ton)	Cooling Load Hours (%)	Cooling Load Hours	Heating Load Capacity (Btuh)	Heating Load Hours (%)	Heating Load Hours	Cooling Airflow Cap. (Cfm)	Cooling Airflow Hours (%)	Cooling Airflow Hours	Heating Airflow Cap. (Cfm)	Heating Airflow Hours (%)	Heating Airflow Hours
0 - 5	5.3	20	967	-55,089	19	807	572.9	0	0	0.0	0	0
5 - 10	10.5	13	644	-110,178	15	652	1,145.8	0	0	0.0	0	0
10 - 15	15.8	13	629	-165,268	17	722	1,718.7	0	0	0.0	0	0
15 - 20	21.1	11	524	-220,357	14	614	2,291.6	0	0	0.0	0	0
20 - 25	26.3	7	329	-275,446	14	582	2,864.5	0	0	0.0	0	0
25 - 30	31.6	8	400	-330,535	8	335	3,437.4	0	0	0.0	0	0
30 - 35	36.9	6	272	-385,624	8	356	4,010.3	0	0	0.0	0	0
35 - 40	42.2	6	316	-440,713	5	235	4,583.2	0	0	0.0	0	0
40 - 45	47.4	5	233	-495,803	0	0	5,156.1	0	0	0.0	0	0
45 - 50	52.7	4	209	-550,892	0	0	5,729.0	0	0	0.0	0	0
50 - 55	58.0	2	109	-605,981	0	0	6,301.9	0	0	0.0	0	0
55 - 60	63.2	2	88	-661,070	0	0	6,874.8	0	0	0.0	0	0
60 - 65	68.5	4	173	-716,159	0	0	7,447.7	0	0	0.0	0	0
65 - 70	73.8	0	23	-771,249	0	0	8,020.6	0	0	0.0	0	0
70 - 75	79.0	0	0	-826,338	0	0	8,593.5	0	0	0.0	0	0
75 - 80	84.3	0	0	-881,427	0	0	9,166.4	0	0	0.0	0	0
80 - 85	89.6	0	0	-936,516	0	0	9,739.3	0	0	0.0	0	0
85 - 90	94.9	0	0	-991,605	0	0	10,312.2	0	0	0.0	0	0
90 - 95	100.1	0	0	-1,046,695	0	0	10,885.1	0	0	0.0	0	0
95 - 100	105.4	0	0	-1,101,784	0	0	11,458.0	100	8,760	0.0	0	0
Hours Off	0.0	0	3,844	0	0	4,457	0.0	0	0	0.0	0	8,760

Main System 2 TRH ~~TERMINAL REHEAT~~

Percent Design Load	Cooling Load Cap. (Ton)	Cooling Load Hours (%)	Cooling Load Hours	Heating Load Capacity (Btuh)	Heating Load Hours (%)	Heating Load Hours	Cooling Airflow Cap. (Cfm)	Cooling Airflow Hours (%)	Cooling Airflow Hours	Heating Airflow Cap. (Cfm)	Heating Airflow Hours (%)	Heating Airflow Hours
0 - 5	4.1	10	693	-46,141	10	773	456.6	0	0	0.0	0	0
5 - 10	8.3	5	338	-92,282	21	1,627	913.3	0	0	0.0	0	0
10 - 15	12.4	8	551	-138,422	23	1,824	1,370.0	0	0	0.0	0	0
15 - 20	16.6	5	368	-184,563	13	1,043	1,826.6	0	0	0.0	0	0
20 - 25	20.7	6	426	-230,704	13	1,018	2,283.3	0	0	0.0	0	0
25 - 30	24.9	5	368	-276,845	7	520	2,739.9	0	0	0.0	0	0
30 - 35	29.0	4	276	-322,985	6	499	3,196.6	0	0	0.0	0	0
35 - 40	33.2	7	483	-369,126	4	308	3,653.2	0	0	0.0	0	0
40 - 45	37.3	3	194	-415,267	2	131	4,109.9	0	0	0.0	0	0
45 - 50	41.5	5	320	-461,408	0	34	4,566.5	0	0	0.0	0	0
50 - 55	45.6	6	398	-507,549	0	32	5,023.2	0	0	0.0	0	0
55 - 60	49.8	6	370	-553,689	0	0	5,479.8	0	0	0.0	0	0
60 - 65	53.9	7	460	-599,830	0	0	5,936.5	0	0	0.0	0	0
65 - 70	58.1	4	275	-645,971	0	0	6,393.1	0	0	0.0	0	0
70 - 75	62.2	3	212	-692,112	0	0	6,849.8	0	0	0.0	0	0
75 - 80	66.4	3	213	-738,252	0	0	7,306.4	0	0	0.0	0	0
80 - 85	70.5	3	214	-784,393	0	0	7,763.1	0	0	0.0	0	0
85 - 90	74.7	2	153	-830,534	0	0	8,219.7	0	0	0.0	0	0
90 - 95	78.8	3	185	-876,675	0	0	8,676.4	0	0	0.0	0	0
95 - 100	83.0	3	216	-922,815	0	0	9,133.0	100	8,760	0.0	0	0
Hours Off	0.0	0	2,047	0	0	951	0.0	0	0	0.0	0	8,760

SYSTEM LOAD PROFILE - ALTERNATIVE 1
BASELINE MODEL

Main System 3 DD DOUBLE DUCT

Percent Design Load	---- Cooling Load ---- Cap. (Ton)	Hours (%)	Hours	------ Heating Load ------ Capacity (Btuh)	Hours (%)	Hours	---- Cooling Airflow ----- Cap. (Cfm)	Hours (%)	Hours	---- Heating Airflow ----- Cap. (Cfm)	Hours (%)	Hours
0 - 5	2.9	0	0	-35,506	33	1,435	854.6	0	0	0.0	0	0
5 - 10	5.7	3	295	-71,012	19	825	1,709.2	0	0	0.0	0	0
10 - 15	8.6	13	1,182	-106,518	17	737	2,563.8	0	0	0.0	0	0
15 - 20	11.4	18	1,578	-142,024	18	772	3,418.4	0	0	0.0	0	0
20 - 25	14.3	11	956	-177,529	12	524	4,273.0	0	0	0.0	0	0
25 - 30	17.2	11	957	-213,035	2	86	5,127.6	0	0	0.0	0	0
30 - 35	20.0	7	636	-248,541	0	0	5,982.2	0	0	0.0	0	0
35 - 40	22.9	6	520	-284,047	0	0	6,836.8	0	0	0.0	0	0
40 - 45	25.7	3	290	-319,553	0	0	7,691.4	0	0	0.0	0	0
45 - 50	28.6	4	341	-355,059	0	0	8,546.0	0	0	0.0	0	0
50 - 55	31.5	4	307	-390,565	0	0	9,400.6	0	0	0.0	0	0
55 - 60	34.3	3	237	-426,071	0	0	10,255.2	0	0	0.0	0	0
60 - 65	37.2	3	227	-461,577	0	0	11,109.8	0	0	0.0	0	0
65 - 70	40.0	4	330	-497,083	0	0	11,964.4	0	0	0.0	0	0
70 - 75	42.9	3	268	-532,589	0	0	12,819.0	0	0	0.0	0	0
75 - 80	45.8	2	205	-568,094	0	0	13,673.6	0	0	0.0	0	0
80 - 85	48.6	1	105	-603,600	0	0	14,528.2	0	0	0.0	0	0
85 - 90	51.5	2	132	-639,106	0	0	15,382.8	0	0	0.0	0	0
90 - 95	54.4	1	105	-674,612	0	0	16,237.4	0	0	0.0	0	0
95 - 100	57.2	1	89	-710,118	0	0	17,092.0	100	8,760	0.0	0	0
Hours Off	0.0	0	0	0	0	4,381	0.0	0	0	0.0	0	8,760

Main System 4 DD DOUBLE DUCT

Percent Design Load	---- Cooling Load ---- Cap. (Ton)	Hours (%)	Hours	------ Heating Load ------ Capacity (Btuh)	Hours (%)	Hours	---- Cooling Airflow ----- Cap. (Cfm)	Hours (%)	Hours	---- Heating Airflow ----- Cap. (Cfm)	Hours (%)	Hours
0 - 5	2.3	0	0	-31,536	19	873	775.4	0	0	0.0	0	0
5 - 10	4.7	4	355	-63,072	24	1,120	1,550.7	0	0	0.0	0	0
10 - 15	7.0	28	2,464	-94,608	13	589	2,326.1	0	0	0.0	0	0
15 - 20	9.4	13	1,138	-126,144	15	704	3,101.4	0	0	0.0	0	0
20 - 25	11.7	12	1,062	-157,679	15	682	3,876.7	0	0	0.0	0	0
25 - 30	14.1	7	640	-189,215	13	593	4,652.1	0	0	0.0	0	0
30 - 35	16.4	5	478	-220,751	1	46	5,427.5	0	0	0.0	0	0
35 - 40	18.7	5	427	-252,287	0	0	6,202.8	0	0	0.0	0	0
40 - 45	21.1	3	280	-283,823	0	0	6,978.2	0	0	0.0	0	0
45 - 50	23.4	2	211	-315,359	0	0	7,753.5	0	0	0.0	0	0
50 - 55	25.8	3	279	-346,895	0	0	8,528.9	0	0	0.0	0	0
55 - 60	28.1	2	198	-378,431	0	0	9,304.2	0	0	0.0	0	0
60 - 65	30.5	2	202	-409,967	0	0	10,079.6	0	0	0.0	0	0
65 - 70	32.8	3	230	-441,502	0	0	10,854.9	0	0	0.0	0	0
70 - 75	35.1	3	240	-473,038	0	0	11,630.3	0	0	0.0	0	0
75 - 80	37.5	1	125	-504,574	0	0	12,405.6	0	0	0.0	0	0
80 - 85	39.8	1	127	-536,110	0	0	13,181.0	0	0	0.0	0	0
85 - 90	42.2	1	110	-567,646	0	0	13,956.3	0	0	0.0	0	0
90 - 95	44.5	1	105	-599,182	0	0	14,731.7	0	0	0.0	0	0
95 - 100	46.9	1	89	-630,718	0	0	15,507.0	100	8,760	0.0	0	0
Hours Off	0.0	0	0	0	0	4,153	0.0	0	0	0.0	0	8,760

SYSTEM LOAD PROFILE - ALTERNATIVE 1
BASELINE MODEL

Main System 5 MZ MULTIZONE

Percent Design Load	---- Cooling Load ---- Cap. (Ton)	Hours (%)	Hours	------ Heating Load ------ Capacity (Btuh)	Hours (%)	Hours	---- Cooling Airflow ----- Cap. (Cfm)	Hours (%)	Hours	---- Heating Airflow ----- Cap. (Cfm)	Hours (%)	Hours
0 - 5	5.3	0	0	-36,196	10	396	1,992.5	0	0	0.0	0	0
5 - 10	10.5	0	34	-72,392	13	491	3,985.0	0	0	0.0	0	0
10 - 15	15.8	28	2,476	-108,588	14	534	5,977.5	0	0	0.0	0	0
15 - 20	21.1	10	904	-144,783	15	558	7,970.0	0	0	0.0	0	0
20 - 25	26.3	9	787	-180,979	14	534	9,962.5	0	0	0.0	0	0
25 - 30	31.6	11	993	-217,175	12	443	11,955.0	0	0	0.0	0	0
30 - 35	36.8	12	1,052	-253,371	7	268	13,947.5	0	0	0.0	0	0
35 - 40	42.1	8	685	-289,567	8	297	15,940.0	0	0	0.0	0	0
40 - 45	47.4	6	493	-325,763	6	245	17,932.5	0	0	0.0	0	0
45 - 50	52.6	3	288	-361,958	2	74	19,925.0	0	0	0.0	0	0
50 - 55	57.9	5	405	-398,154	0	0	21,917.5	0	0	0.0	0	0
55 - 60	63.2	2	173	-434,350	0	0	23,910.0	0	0	0.0	0	0
60 - 65	68.4	2	167	-470,546	0	0	25,902.5	0	0	0.0	0	0
65 - 70	73.7	1	130	-506,742	0	0	27,895.0	0	0	0.0	0	0
70 - 75	79.0	2	173	-542,938	0	0	29,887.5	0	0	0.0	0	0
75 - 80	84.2	0	0	-579,134	0	0	31,880.0	0	0	0.0	0	0
80 - 85	89.5	0	0	-615,329	0	0	33,872.5	0	0	0.0	0	0
85 - 90	94.8	0	0	-651,525	0	0	35,865.0	0	0	0.0	0	0
90 - 95	100.0	0	0	-687,721	0	0	37,857.5	0	0	0.0	0	0
95 - 100	105.3	0	0	-723,917	0	0	39,850.0	100	8,760	0.0	0	0
Hours Off	0.0	0	0	0	0	4,920	0.0	0	0	0.0	0	8,760

Main System 6 MZ MULTIZONE

Percent Design Load	---- Cooling Load ---- Cap. (Ton)	Hours (%)	Hours	------ Heating Load ------ Capacity (Btuh)	Hours (%)	Hours	---- Cooling Airflow ----- Cap. (Cfm)	Hours (%)	Hours	---- Heating Airflow ----- Cap. (Cfm)	Hours (%)	Hours
0 - 5	2.7	29	2,008	-24,664	15	784	451.3	0	0	0.0	0	0
5 - 10	5.4	21	1,421	-49,328	11	561	902.6	0	0	0.0	0	0
10 - 15	8.0	9	638	-73,993	11	550	1,353.9	0	0	0.0	0	0
15 - 20	10.7	6	443	-98,657	15	775	1,805.2	0	0	0.0	0	0
20 - 25	13.4	8	523	-123,321	15	784	2,256.5	0	0	0.0	0	0
25 - 30	16.1	5	326	-147,985	18	957	2,707.8	0	0	0.0	0	0
30 - 35	18.8	6	411	-172,650	15	772	3,159.1	0	0	0.0	0	0
35 - 40	21.5	5	308	-197,314	0	0	3,610.4	0	0	0.0	0	0
40 - 45	24.1	3	212	-221,978	0	0	4,061.7	0	0	0.0	0	0
45 - 50	26.8	2	138	-246,642	0	0	4,513.0	0	0	0.0	0	0
50 - 55	29.5	1	96	-271,307	0	0	4,964.3	0	0	0.0	0	0
55 - 60	32.2	2	109	-295,971	0	0	5,415.6	0	0	0.0	0	0
60 - 65	34.9	1	85	-320,635	0	0	5,866.9	0	0	0.0	0	0
65 - 70	37.6	1	86	-345,299	0	0	6,318.2	0	0	0.0	0	0
70 - 75	40.2	0	23	-369,964	0	0	6,769.5	0	0	0.0	0	0
75 - 80	42.9	0	0	-394,628	0	0	7,220.8	0	0	0.0	0	0
80 - 85	45.6	0	0	-419,292	0	0	7,672.1	0	0	0.0	0	0
85 - 90	48.3	0	0	-443,956	0	0	8,123.4	0	0	0.0	0	0
90 - 95	51.0	0	0	-468,621	0	0	8,574.7	0	0	0.0	0	0
95 - 100	53.7	0	0	-493,285	0	0	9,026.0	100	8,760	0.0	0	0
Hours Off	0.0	0	1,933	0	0	3,577	0.0	0	0	0.0	0	8,760

SYSTEM LOAD PROFILE - ALTERNATIVE 1
BASELINE MODEL

Main System 7 MZ MULTIZONE

Percent Design Load	---- Cooling Load ---- Cap. (Ton)	Hours (%)	Hours	------ Heating Load ------ Capacity (Btuh)	Hours (%)	Hours	---- Cooling Airflow ----- Cap. (Cfm)	Hours (%)	Hours	---- Heating Airflow ----- Cap. (Cfm)	Hours (%)	Hours
0 - 5	7.4	0	0	-47,951	11	397	2,041.7	0	0	0.0	0	0
5 - 10	14.9	20	1,785	-95,903	14	488	4,083.3	0	0	0.0	0	0
10 - 15	22.3	13	1,181	-143,854	15	537	6,125.0	0	0	0.0	0	0
15 - 20	29.7	14	1,234	-191,806	16	551	8,166.6	0	0	0.0	0	0
20 - 25	37.2	5	447	-239,757	14	478	10,208.2	0	0	0.0	0	0
25 - 30	44.6	8	738	-287,709	8	273	12,249.9	0	0	0.0	0	0
30 - 35	52.0	7	614	-335,660	8	275	14,291.6	0	0	0.0	0	0
35 - 40	59.5	6	512	-383,612	7	259	16,333.2	0	0	0.0	0	0
40 - 45	66.9	5	458	-431,563	6	217	18,374.9	0	0	0.0	0	0
45 - 50	74.3	5	465	-479,515	0	9	20,416.5	0	0	0.0	0	0
50 - 55	81.8	5	397	-527,466	0	0	22,458.2	0	0	0.0	0	0
55 - 60	89.2	3	269	-575,418	0	0	24,499.8	0	0	0.0	0	0
60 - 65	96.7	3	229	-623,370	0	0	26,541.5	0	0	0.0	0	0
65 - 70	104.1	1	128	-671,321	0	0	28,583.1	0	0	0.0	0	0
70 - 75	111.5	1	107	-719,273	0	0	30,624.8	0	0	0.0	0	0
75 - 80	119.0	1	127	-767,224	0	0	32,666.4	0	0	0.0	0	0
80 - 85	126.4	1	69	-815,175	0	0	34,708.1	0	0	0.0	0	0
85 - 90	133.8	0	0	-863,127	0	0	36,749.7	0	0	0.0	0	0
90 - 95	141.3	0	0	-911,079	0	0	38,791.4	0	0	0.0	0	0
95 - 100	148.7	0	0	-959,030	0	0	40,833.0	100	8,760	0.0	0	0
Hours Off	0.0	0	0	0	0	5,276	0.0	0	0	0.0	0	8,760

Main System 8 MZ MULTIZONE

Percent Design Load	---- Cooling Load ---- Cap. (Ton)	Hours (%)	Hours	------ Heating Load ------ Capacity (Btuh)	Hours (%)	Hours	---- Cooling Airflow ----- Cap. (Cfm)	Hours (%)	Hours	---- Heating Airflow ----- Cap. (Cfm)	Hours (%)	Hours
0 - 5	2.8	0	0	-20,827	11	448	1,028.1	0	0	0.0	0	0
5 - 10	5.6	2	186	-41,655	12	462	2,056.2	0	0	0.0	0	0
10 - 15	8.4	31	2,745	-62,482	15	613	3,084.3	0	0	0.0	0	0
15 - 20	11.2	6	556	-83,310	14	573	4,112.4	0	0	0.0	0	0
20 - 25	14.0	11	977	-104,137	12	472	5,140.5	0	0	0.0	0	0
25 - 30	16.8	11	933	-124,964	13	506	6,168.6	0	0	0.0	0	0
30 - 35	19.6	7	606	-145,792	6	236	7,196.7	0	0	0.0	0	0
35 - 40	22.4	7	618	-166,619	8	327	8,224.8	0	0	0.0	0	0
40 - 45	25.2	4	382	-187,447	6	252	9,252.9	0	0	0.0	0	0
45 - 50	28.0	4	382	-208,274	2	74	10,281.0	0	0	0.0	0	0
50 - 55	30.8	4	381	-229,102	0	0	11,309.1	0	0	0.0	0	0
55 - 60	33.6	4	330	-249,929	0	0	12,337.2	0	0	0.0	0	0
60 - 65	36.4	2	193	-270,756	0	0	13,365.3	0	0	0.0	0	0
65 - 70	39.2	2	146	-291,584	0	0	14,393.4	0	0	0.0	0	0
70 - 75	42.0	1	65	-312,411	0	0	15,421.5	0	0	0.0	0	0
75 - 80	44.7	2	151	-333,239	0	0	16,449.6	0	0	0.0	0	0
80 - 85	47.5	1	109	-354,066	0	0	17,477.7	0	0	0.0	0	0
85 - 90	50.3	0	0	-374,893	0	0	18,505.8	0	0	0.0	0	0
90 - 95	53.1	0	0	-395,721	0	0	19,533.9	0	0	0.0	0	0
95 - 100	55.9	0	0	-416,548	0	0	20,562.0	100	8,760	0.0	0	0
Hours Off	0.0	0	0	0	0	4,797	0.0	0	0	0.0	0	8,760

SYSTEM TOTALS LOAD PROFILE - ALTERNATIVE 1
BASELINE MODEL

S Y S T E M   L O A D   P R O F I L E

System Totals

Percent Design Load	Cooling Load Cap. (Ton)	Cooling Load Hours (%)	Cooling Load Hours	Heating Load Capacity (Btuh)	Heating Load Hours (%)	Heating Load Hours	Cooling Airflow Cap. (Cfm)	Cooling Airflow Hours (%)	Cooling Airflow Hours	Heating Airflow Cap. (Cfm)	Heating Airflow Hours (%)	Heating Airflow Hours
0 - 5	32.8	0	0	-297,911	52	4,065	8,173.0	0	0	0.0	0	0
5 - 10	65.6	26	2,272	-595,821	11	868	16,346.1	0	0	0.0	0	0
10 - 15	98.4	15	1,315	-893,732	10	756	24,519.2	0	0	0.0	0	0
15 - 20	131.2	11	1,005	-1,191,643	8	658	32,692.2	0	0	0.0	0	0
20 - 25	164.0	7	575	-1,489,553	7	585	40,865.2	0	0	0.0	0	0
25 - 30	196.8	8	714	-1,787,464	5	374	49,038.3	0	0	0.0	0	0
30 - 35	229.6	6	517	-2,085,375	4	296	57,211.4	0	0	0.0	0	0
35 - 40	262.4	4	376	-2,383,286	3	252	65,384.4	0	0	0.0	0	0
40 - 45	295.2	5	438	-2,681,197	0	21	73,557.5	0	0	0.0	0	0
45 - 50	328.0	4	326	-2,979,107	0	0	81,730.5	0	0	0.0	0	0
50 - 55	360.8	4	308	-3,277,018	0	0	89,903.6	0	0	0.0	0	0
55 - 60	393.6	3	292	-3,574,929	0	0	98,076.6	0	0	0.0	0	0
60 - 65	426.4	2	211	-3,872,840	0	0	106,249.7	0	0	0.0	0	0
65 - 70	459.2	1	108	-4,170,751	0	0	114,422.7	0	0	0.0	0	0
70 - 75	492.0	1	109	-4,468,662	0	0	122,595.8	0	0	0.0	0	0
75 - 80	524.8	2	148	-4,766,571	0	0	130,768.8	0	0	0.0	0	0
80 - 85	557.6	1	46	-5,064,482	0	0	138,941.9	0	0	0.0	0	0
85 - 90	590.4	0	0	-5,362,394	0	0	147,114.9	0	0	0.0	0	0
90 - 95	623.2	0	0	-5,660,305	0	0	155,288.0	0	0	0.0	0	0
95 - 100	656.0	0	0	-5,958,215	0	0	163,461.0	100	8,760	0.0	0	0
Hours Off	0.0	0	0	0	0	885	0.0	0	0	0.0	0	8,760

BUILDING COOL-HEAT DEMAND - ALTERNATIVE 1
BASELINE MODEL

January			------ Design -----		----- Weekday -----		----- Saturday----		------ Sunday -----		------ Monday -----	
Hour	OADB	OAWB	Htg Btuh	Clg Ton	Htg Btuh	Clg Ton	Htg Btuh	Clg Ton	Htg Btuh	Clg Ton	Htg Btuh	Clg Ton
1	42.6	39.9	-1,429,445	50.6	-1,976,341	47.3	-1,981,861	47.4	-2,011,151	47.4	-1,978,873	47.4
2	41.4	38.7	-1,795,620	48.5	-2,146,285	46.4	-2,133,486	46.5	-2,133,419	46.5	-2,153,592	46.5
3	40.7	38.1	-1,575,065	47.3	-2,147,770	45.3	-2,156,432	45.4	-2,130,530	45.4	-2,123,153	45.4
4	40.4	37.8	-1,882,677	46.1	-2,213,713	44.1	-2,202,781	44.2	-2,230,458	44.2	-2,245,730	44.2
5	40.8	38.1	-1,660,262	44.7	-2,176,526	42.8	-2,184,812	42.9	-2,169,349	42.8	-2,157,982	42.8
6	41.8	39.1	-1,862,672	44.5	-2,141,921	43.0	-2,152,871	41.8	-2,160,926	41.8	-2,141,944	43.0
7	43.4	40.7	-1,324,200	59.0	-1,697,081	55.9	-2,023,023	40.6	-2,012,229	40.6	-1,702,463	55.9
8	45.4	42.8	-1,098,025	83.2	-1,339,991	77.1	-1,858,296	40.7	-1,871,155	40.7	-1,338,981	77.1
9	47.7	44.9	-863,272	87.1	-1,019,007	79.7	-1,339,608	56.6	-1,453,681	52.6	-1,010,047	79.6
10	50.2	46.6	-643,544	90.7	-1,108,813	82.7	-1,227,317	57.0	-1,322,712	52.7	-1,108,813	82.7
11	52.5	47.9	-511,804	98.6	-660,508	87.0	-1,085,423	58.2	-1,030,194	53.7	-671,611	86.9
12	54.5	49.3	-313,768	108.2	-761,749	91.6	-871,123	60.4	-964,468	55.6	-752,074	91.6
13	56.1	50.5	-230,781	117.5	-446,388	97.7	-752,032	64.9	-764,567	59.6	-446,388	97.7
14	57.1	51.1	-138,691	127.7	-530,652	103.7	-785,571	46.4	-814,895	46.2	-530,652	103.1
15	57.5	50.8	-117,358	135.8	-469,520	107.6	-817,667	49.4	-788,690	49.3	-479,918	107.6
16	57.2	50.4	-130,609	136.9	-591,703	109.2	-845,332	51.7	-878,450	51.7	-580,273	109.2
17	56.5	49.9	-300,113	131.4	-500,704	106.8	-902,457	52.1	-843,875	52.1	-510,195	106.8
18	55.3	49.7	-371,579	122.0	-764,735	102.1	-1,093,856	50.6	-1,098,878	50.6	-752,051	102.1
19	53.8	49.3	-716,354	90.3	-1,027,900	71.2	-1,129,154	49.7	-1,153,087	49.7	-1,042,312	71.2
20	52.0	48.2	-975,013	62.1	-1,293,410	51.4	-1,348,311	50.1	-1,345,607	50.1	-1,278,956	51.4
21	50.0	46.6	-1,119,588	58.2	-1,435,830	51.3	-1,414,016	50.2	-1,419,191	50.2	-1,450,050	51.3
22	47.9	44.8	-1,284,863	55.4	-1,605,938	49.9	-1,646,187	50.1	-1,638,922	50.1	-1,592,112	49.9
23	45.9	43.0	-1,358,481	53.5	-1,755,193	49.6	-1,720,964	49.8	-1,715,631	49.8	-1,768,577	49.6
24	44.1	41.2	-1,557,509	50.8	-1,926,527	48.2	-1,868,064	49.2	-1,895,886	49.3	-1,913,351	48.2

February			------ Design -----		----- Weekday -----		----- Saturday----		------ Sunday -----		------ Monday -----	
Hour	OADB	OAWB	Htg Btuh	Clg Ton	Htg Btuh	Clg Ton	Htg Btuh	Clg Ton	Htg Btuh	Clg Ton	Htg Btuh	Clg Ton
1	45.0	41.6	-1,640,022	51.9	-1,742,617	46.8	-1,864,379	47.0	-1,775,736	47.0	-1,869,275	46.9
2	43.3	40.3	-1,762,636	50.2	-2,098,749	46.3	-1,994,058	46.4	-2,065,266	46.4	-1,996,087	46.4
3	41.8	39.1	-1,804,280	48.4	-1,974,738	46.0	-2,070,580	46.1	-2,003,840	46.1	-2,072,622	46.1
4	40.5	38.0	-1,842,258	47.2	-2,303,886	45.1	-2,192,654	45.2	-2,270,748	45.2	-2,194,733	45.1
5	39.6	37.1	-1,898,307	45.9	-2,122,335	44.0	-2,246,653	44.1	-2,151,763	44.1	-2,248,794	44.1
6	39.0	36.8	-1,855,353	45.7	-2,395,731	44.1	-2,300,931	43.0	-2,387,178	43.0	-2,267,415	44.2
7	38.8	36.6	-1,513,445	59.1	-1,898,127	55.7	-2,305,876	42.4	-2,235,280	42.4	-2,017,981	55.7
8	39.4	37.2	-1,110,659	83.1	-1,554,302	74.0	-2,147,933	43.3	-2,202,949	43.3	-1,485,549	74.0
9	40.9	38.1	-927,999	86.5	-1,522,581	76.0	-1,803,387	57.0	-1,930,553	53.6	-1,493,293	76.0
10	43.3	39.3	-713,117	89.8	-1,358,988	78.6	-1,650,019	58.2	-1,686,618	54.5	-1,358,845	78.6
11	46.2	40.8	-559,388	97.1	-1,021,492	81.9	-1,424,697	59.7	-1,433,451	55.6	-1,117,882	81.9
12	49.3	42.7	-340,231	107.9	-991,946	86.8	-1,358,209	62.2	-1,335,490	57.7	-991,946	86.8
13	52.2	44.9	-266,875	118.1	-746,812	91.3	-891,964	63.9	-1,091,926	59.2	-692,062	91.3
14	54.5	46.8	-167,736	128.3	-646,502	96.4	-1,067,300	46.0	-964,602	45.9	-646,502	96.4
15	56.1	47.8	-138,805	136.6	-482,612	102.4	-766,930	49.0	-868,030	48.9	-482,612	102.4
16	56.6	48.0	-154,768	139.6	-536,091	105.7	-958,524	51.2	-807,691	51.2	-592,642	105.7
17	56.4	47.7	-244,361	135.1	-575,240	105.4	-761,728	52.1	-949,923	52.1	-496,235	105.4
18	55.9	47.7	-393,191	124.9	-713,084	101.4	-1,192,027	50.0	-1,020,674	50.0	-787,752	101.4
19	54.9	48.6	-636,028	93.9	-996,663	71.7	-984,861	50.1	-1,107,888	50.1	-907,370	71.7
20	53.7	48.5	-1,140,169	68.6	-1,159,962	49.9	-1,299,777	48.6	-1,194,007	48.6	-1,251,774	49.9
21	52.2	47.8	-1,069,688	61.9	-1,303,052	49.8	-1,196,812	48.7	-1,303,925	48.7	-1,211,415	49.8
22	50.5	46.7	-1,489,186	58.7	-1,430,684	48.5	-1,550,266	48.8	-1,443,457	48.8	-1,520,285	48.5
23	48.7	44.9	-1,339,654	56.5	-1,582,404	48.5	-1,446,465	48.7	-1,553,419	48.7	-1,494,278	48.5
24	46.8	43.3	-1,734,560	53.2	-1,736,011	47.2	-1,809,154	48.5	-1,703,500	48.5	-1,822,838	47.2

BUILDING COOL-HEAT DEMAND - ALTERNATIVE 1
BASELINE MODEL

March			------ Design -----		----- Weekday -----		----- Saturday----		------ Sunday -----		------ Monday -----	
Hour	OADB	OAWB	Htg Btuh	Clg Ton	Htg Btuh	Clg Ton	Htg Btuh	Clg Ton	Htg Btuh	Clg Ton	Htg Btuh	Clg Ton
1	55.3	52.2	-760,624	60.0	-1,093,472	52.5	-1,058,574	54.7	-1,071,687	54.5	-1,060,037	54.4
2	53.5	50.4	-1,053,787	56.7	-1,187,324	49.7	-1,227,480	50.5	-1,214,438	50.5	-1,229,125	50.4
3	52.0	49.2	-903,076	54.3	-1,361,270	49.6	-1,313,882	50.1	-1,326,767	50.1	-1,315,553	50.0
4	50.7	48.0	-1,171,311	51.8	-1,401,637	49.1	-1,448,976	49.5	-1,436,135	49.5	-1,450,752	49.4
5	49.8	46.9	-980,608	50.1	-1,537,838	48.2	-1,484,383	48.4	-1,497,123	48.4	-1,486,108	48.4
6	49.2	46.4	-1,145,699	49.2	-1,516,176	48.7	-1,586,139	47.3	-1,573,963	47.3	-1,567,704	48.7
7	49.0	46.4	-682,375	69.8	-1,307,886	64.8	-1,535,962	46.8	-1,546,728	46.8	-1,260,690	64.8
8	49.8	46.7	-546,033	104.2	-813,273	89.7	-1,371,981	47.8	-1,371,981	47.8	-827,460	89.8
9	52.0	47.8	-265,094	112.6	-933,968	93.2	-959,735	65.2	-1,132,964	60.7	-952,829	93.3
10	55.3	49.6	-136,422	124.0	-517,925	98.7	-948,740	66.8	-787,376	61.7	-517,925	98.7
11	59.2	52.1	-43,140	147.0	-455,192	107.7	-481,421	71.4	-670,547	65.1	-446,453	108.3
12	63.1	54.5	-7,526	171.6	-143,608	118.2	-318,776	75.0	-266,848	67.6	-143,608	118.5
13	66.4	56.9	-2,585	193.1	-116,607	137.5	-150,217	88.2	-187,535	77.4	-116,607	137.5
14	68.6	58.5	-3,426	208.7	-28,799	155.4	-55,699	69.2	-47,332	68.1	-37,166	155.5
15	69.4	58.7	-3,084	218.6	-20,458	165.1	-26,509	76.7	-26,509	75.9	-20,458	165.1
16	69.2	58.6	-4,391	220.2	-112,348	166.3	-112,864	78.4	-122,849	78.0	-102,362	166.3
17	68.6	58.8	-5,175	212.7	-113,968	162.2	-142,886	77.7	-132,687	77.5	-124,166	162.2
18	67.7	58.7	-7,069	193.6	-134,503	161.3	-156,071	76.9	-167,412	76.6	-123,162	161.3
19	66.4	59.0	-104,855	137.5	-197,626	114.0	-269,868	72.3	-256,279	72.1	-211,215	114.0
20	64.9	59.3	-233,248	97.8	-359,952	79.4	-304,443	74.0	-318,793	73.9	-345,602	79.4
21	63.1	58.5	-384,107	86.7	-429,944	69.5	-494,986	67.3	-480,735	67.3	-444,195	69.5
22	61.2	57.2	-513,050	76.7	-639,382	64.8	-597,493	65.3	-611,457	65.3	-625,418	64.8
23	59.2	55.4	-664,117	71.6	-754,290	64.1	-772,268	64.7	-758,535	64.7	-768,023	64.1
24	57.2	53.9	-758,692	64.8	-947,640	57.0	-907,201	59.2	-920,572	59.2	-934,269	57.0

April			------- Design -----		----- Weekday -----		----- Saturday----		------ Sunday -----		------ Monday -----	
Hour	OADB	OAWB	Htg Btuh	Clg Ton	Htg Btuh	Clg Ton	Htg Btuh	Clg Ton	Htg Btuh	Clg Ton	Htg Btuh	Clg Ton
1	63.1	60.6	-168,426	87.2	-476,514	82.3	-586,483	81.4	-538,280	81.4	-587,215	81.2
2	62.0	59.6	-218,879	81.4	-545,654	75.3	-464,136	73.9	-512,403	73.8	-465,159	73.7
3	61.1	58.8	-222,128	76.6	-665,815	70.6	-728,196	69.7	-679,417	69.7	-729,342	69.5
4	60.5	58.3	-274,325	71.6	-661,433	66.8	-606,839	67.4	-655,271	67.4	-608,077	67.3
5	60.4	58.4	-247,713	71.4	-677,789	67.6	-771,748	65.0	-725,917	65.0	-727,430	67.8
6	60.9	58.7	-229,818	102.9	-497,916	95.1	-585,355	62.1	-627,783	62.1	-443,719	95.2
7	62.3	60.1	-37,803	160.6	-372,924	153.2	-497,810	70.7	-522,116	70.7	-348,618	152.7
8	64.6	61.8	-133,007	186.2	-109,986	166.0	-219,188	108.0	-186,645	98.4	-171,371	165.8
9	67.3	63.2	-1,152	205.4	-47,846	179.5	-124,600	119.0	-124,793	106.2	-72,856	179.5
10	70.3	64.3	0	213.1	-98,731	214.3	-100,353	149.6	-100,809	134.0	-98,731	214.3
11	73.0	65.3	0	244.5	-25,675	238.7	0	175.9	-25,675	159.5	0	238.7
12	75.2	66.1	0	266.1	0	255.6	0	194.6	0	178.3	0	255.6
13	76.7	66.6	0	283.6	0	268.5	0	165.3	0	163.4	0	268.5
14	77.2	66.9	0	298.9	0	277.3	0	175.2	0	174.6	0	277.3
15	77.0	66.4	0	307.9	0	278.7	0	177.6	0	177.4	0	278.7
16	76.5	66.2	0	307.0	0	274.0	0	176.8	0	176.7	0	274.0
17	75.6	65.8	0	299.6	-158,996	252.9	-126,897	161.8	-157,072	161.8	-126,897	252.9
18	74.4	66.0	0	245.6	-32,510	207.2	-77,287	160.3	-32,510	160.3	-77,287	207.2
19	73.0	66.1	0	197.1	-182,770	160.5	-141,599	149.1	-182,770	149.1	-141,599	160.5
20	71.4	66.3	0	184.1	-33,714	150.4	-80,199	142.5	-33,714	142.5	-80,199	150.4
21	69.7	65.6	-123,097	156.0	-241,834	128.9	-192,696	129.7	-241,834	129.7	-192,696	128.9
22	67.9	64.6	-91,001	135.9	-107,872	110.6	-157,090	112.6	-107,184	112.6	-157,778	110.6
23	66.2	63.4	-174,656	117.8	-391,665	97.6	-334,207	103.0	-383,135	103.0	-342,737	97.6
24	64.6	62.0	-111,436	107.8	-245,347	86.8	-292,731	86.9	-244,752	86.9	-293,326	86.8

BUILDING COOL-HEAT DEMAND - ALTERNATIVE 1
BASELINE MODEL

May			Design		Weekday		Saturday		Sunday		Monday	
Hour	OADB	OAWB	Htg Btuh	Clg Ton	Htg Btuh	Clg Ton	Htg Btuh	Clg Ton	Htg Btuh	Clg Ton	Htg Btuh	Clg Ton
1	67.4	66.0	-180,838	152.9	-159,586	114.1	-279,642	112.5	-279,512	111.9	-279,931	111.7
2	66.4	64.6	-155,307	146.0	-372,220	104.1	-237,310	99.3	-237,277	99.6	-237,735	99.4
3	65.6	63.5	-42,451	125.8	-225,200	97.3	-369,259	94.1	-369,259	94.2	-370,047	94.0
4	65.0	62.4	-221,696	116.1	-450,305	95.3	-295,726	92.3	-295,726	92.3	-299,659	92.2
5	64.8	62.3	-43,135	115.5	-258,639	96.6	-421,086	89.7	-421,086	89.7	-408,982	93.3
6	65.2	62.1	-197,028	167.3	-291,985	136.8	-225,718	90.0	-225,718	90.0	-160,134	136.0
7	66.2	62.4	0	242.5	-167,555	204.6	-248,098	101.2	-248,098	101.2	-181,930	205.4
8	68.0	62.5	-118,619	248.5	-19,204	206.1	-63,735	145.4	-70,870	131.6	-27,670	206.3
9	70.6	63.4	0	268.0	-29,645	228.4	-30,630	164.7	-30,906	148.7	-29,645	228.4
10	73.7	64.2	0	293.5	-87,747	254.0	-87,747	192.0	-87,747	175.6	-87,747	253.9
11	77.1	65.5	-88,672	323.1	0	282.3	0	221.6	0	205.0	0	282.2
12	80.3	67.0	0	354.2	0	323.1	0	261.3	0	243.9	0	323.1
13	82.8	68.7	0	397.7	-85,988	346.9	-85,988	241.2	-85,988	239.3	-85,988	346.9
14	84.4	69.4	-93,975	420.5	0	364.9	0	261.1	0	260.6	0	364.8
15	85.0	69.4	0	432.1	-88,192	373.5	-88,192	270.9	-88,192	270.8	-88,192	373.4
16	84.4	69.7	-107,389	428.8	0	380.0	0	278.9	0	278.9	0	380.0
17	83.0	70.0	-79,036	416.5	-126,270	364.7	-126,270	267.9	-126,270	267.9	-126,270	364.6
18	80.7	70.5	-87,259	351.3	-29,318	300.5	-29,318	253.5	-29,318	253.5	-29,318	300.5
19	78.1	71.0	-95,676	291.9	-218,002	235.3	-228,670	222.8	-228,670	222.8	-228,670	235.3
20	75.5	71.9	-101,030	272.0	-106,824	213.1	-106,824	203.8	-106,824	203.8	-106,824	213.1
21	73.3	71.8	-99,040	247.4	-85,994	192.8	-85,994	190.4	-85,994	190.4	-85,994	192.8
22	71.2	70.4	-192,060	212.5	-166,528	162.0	-166,528	160.3	-166,528	160.3	-166,528	162.0
23	69.6	69.0	-88,543	188.7	-106,117	133.7	-106,117	137.2	-106,117	137.2	-106,117	133.7
24	68.4	67.5	-198,198	175.2	-217,687	124.8	-218,202	122.9	-218,202	122.9	-217,687	124.8

June			Design		Weekday		Saturday		Sunday		Monday	
Hour	OADB	OAWB	Htg Btuh	Clg Ton	Htg Btuh	Clg Ton	Htg Btuh	Clg Ton	Htg Btuh	Clg Ton	Htg Btuh	Clg Ton
1	73.1	70.5	-194,572	227.6	-79,047	184.3	-168,426	187.0	-79,047	184.1	-168,426	183.7
2	72.2	69.6	-128,790	219.3	-123,389	173.7	-32,484	171.7	-123,390	169.6	-32,484	169.3
3	71.5	68.6	-181,120	207.6	-140,272	163.3	-232,245	162.3	-140,272	159.8	-232,245	158.6
4	71.0	68.2	-125,692	199.4	-129,941	148.7	-36,003	147.0	-129,941	144.6	-36,003	145.4
5	70.8	68.0	-174,428	199.4	-143,940	147.0	-236,345	141.0	-144,014	139.1	-236,270	144.5
6	71.1	68.1	-117,672	249.2	-108,441	202.1	-31,651	141.4	-108,441	142.1	-31,651	201.5
7	72.0	68.6	0	321.1	-113,105	294.4	-113,105	170.6	-113,105	170.9	-113,105	294.9
8	73.7	69.1	-129,113	336.5	0	293.8	0	231.1	0	214.5	0	293.5
9	76.0	70.7	0	343.7	-79,598	319.9	-79,598	253.2	-79,598	235.5	-79,598	319.5
10	78.7	72.9	-100,527	383.2	0	348.0	0	281.7	0	263.5	0	347.6
11	81.7	74.6	0	414.1	0	371.7	0	307.5	0	289.3	0	371.3
12	84.6	75.3	-89,060	444.3	-106,782	401.7	-106,782	338.4	-106,782	320.1	-106,782	401.3
13	86.7	75.7	0	487.7	0	450.3	0	334.7	0	333.1	0	450.0
14	88.2	75.7	-85,853	508.8	-92,234	485.2	-92,234	371.5	-92,234	371.2	-92,234	484.9
15	88.7	76.2	0	537.7	0	505.4	0	392.0	0	391.9	0	505.1
16	88.2	75.2	-115,375	535.5	-126,095	481.9	-126,095	375.7	-126,095	375.7	-126,095	481.6
17	86.9	74.7	-87,287	506.7	-84,623	466.3	-84,623	363.0	-84,623	363.1	-84,623	466.0
18	84.9	74.3	-99,266	439.8	-115,558	387.3	-115,558	338.7	-115,558	338.7	-115,558	387.0
19	82.6	74.4	-109,051	378.3	-91,532	333.0	-91,532	318.9	-91,532	318.9	-91,532	332.7
20	80.3	74.8	-116,793	345.7	-119,953	300.0	-188,157	290.4	-119,953	290.3	-188,157	299.7
21	78.3	74.4	-115,960	319.7	-188,147	270.2	-92,314	266.5	-188,147	266.5	-92,314	269.9
22	76.5	73.5	-137,536	296.4	-117,698	247.3	-199,703	245.5	-117,698	245.5	-199,703	247.0
23	75.1	72.7	-108,376	273.1	-167,998	226.5	-83,710	230.5	-167,998	230.5	-83,710	226.3
24	74.0	71.3	-224,530	247.9	-113,142	206.6	-200,033	202.8	-113,142	202.8	-200,033	206.4

BUILDING COOL-HEAT DEMAND - ALTERNATIVE 1
BASELINE MODEL

July			------ Design -----		----- Weekday -----		----- Saturday----		------ Sunday -----		------ Monday -----	
Hour	OADB	OAWB	Htg Btuh	Clg Ton	Htg Btuh	Clg Ton	Htg Btuh	Clg Ton	Htg Btuh	Clg Ton	Htg Btuh	Clg Ton
1	74.0	72.9	-106,743	254.9	-156,345	206.7	-82,076	209.7	-82,076	207.4	-82,076	207.0
2	73.2	71.6	-215,081	238.8	-123,985	192.6	-203,113	191.0	-203,113	189.0	-203,113	188.6
3	72.6	70.7	-102,407	229.2	-157,550	183.7	-77,740	181.8	-77,740	179.5	-77,740	179.1
4	72.1	70.0	-216,581	221.5	-46,108	165.8	-126,911	167.0	-126,911	164.6	-126,911	162.9
5	72.0	69.6	-96,962	222.0	-217,377	167.8	-138,588	157.9	-138,588	157.2	-138,588	165.4
6	72.3	69.4	-195,340	269.6	-42,424	223.1	-113,579	161.8	-113,579	162.4	-113,579	222.6
7	73.1	70.0	-81,014	344.4	-117,703	320.3	-117,703	192.1	-117,703	192.3	-117,703	320.9
8	74.5	70.0	0	357.7	0	321.3	0	256.5	0	238.7	0	321.0
9	76.5	70.7	-122,890	378.6	-87,643	339.3	-87,643	270.8	-87,643	252.5	-87,643	339.0
10	78.8	71.5	0	401.4	0	360.8	0	293.6	0	275.0	0	360.5
11	81.4	73.0	-95,103	428.0	0	400.6	0	332.9	0	313.8	0	400.3
12	83.9	74.3	0	473.6	-106,814	442.4	-106,814	374.9	-106,814	355.3	-106,814	442.1
13	85.8	76.1	-87,552	516.2	0	481.7	0	359.7	0	358.4	0	481.5
14	87.0	77.3	0	537.3	-89,307	498.7	-89,307	382.5	-89,307	382.2	-89,307	498.4
15	87.5	77.9	-95,631	560.6	0	519.9	0	402.5	0	402.5	0	519.6
16	87.0	77.9	0	546.8	-121,812	510.8	-121,812	398.8	-121,812	398.8	-121,812	510.6
17	85.9	78.1	-144,717	534.4	-81,245	495.4	-81,245	387.8	-81,245	387.8	-81,245	495.1
18	84.2	77.6	-98,838	467.6	-113,598	411.2	-113,598	362.0	-113,598	362.0	-113,598	411.0
19	82.2	77.7	-108,306	390.6	-90,788	343.0	-90,788	330.1	-90,788	330.1	-90,788	342.8
20	80.2	78.0	-117,475	372.5	-204,453	323.1	-195,275	313.4	-195,275	313.4	-195,275	322.9
21	78.5	77.5	-117,849	335.7	-93,182	293.7	-93,182	290.7	-93,182	290.7	-93,182	293.4
22	76.9	76.6	-137,029	311.2	-203,861	264.6	-203,861	263.0	-203,861	263.0	-203,861	264.3
23	75.7	75.3	-169,545	290.3	-86,553	234.7	-86,553	239.0	-86,553	239.0	-86,553	234.4
24	74.8	74.1	-147,237	264.7	-202,765	225.7	-202,765	221.7	-202,765	221.7	-202,765	225.4

August			------ Design -----		----- Weekday -----		----- Saturday----		------ Sunday -----		------ Monday -----	
Hour	OADB	OAWB	Htg Btuh	Clg Ton	Htg Btuh	Clg Ton	Htg Btuh	Clg Ton	Htg Btuh	Clg Ton	Htg Btuh	Clg Ton
1	74.4	72.7	-107,361	258.6	-122,810	212.6	-204,160	214.8	-204,160	212.8	-204,160	212.4
2	73.5	71.6	-212,744	239.9	-160,532	197.5	-80,919	195.9	-80,919	194.0	-80,919	193.6
3	72.9	70.9	-102,531	231.3	-122,959	187.4	-203,169	185.7	-203,169	183.3	-203,169	183.0
4	72.4	70.2	-215,396	223.2	-158,762	176.7	-77,616	178.9	-77,616	176.5	-77,616	174.6
5	72.2	69.6	-96,867	212.7	-43,779	173.8	-122,389	164.9	-122,389	164.2	-122,389	171.4
6	72.5	69.6	-199,631	267.4	-205,758	226.6	-132,821	164.5	-132,821	165.2	-132,821	226.1
7	73.4	70.3	-84,366	344.7	-23,092	321.7	-23,092	193.7	-23,092	193.8	-23,092	322.2
8	74.9	71.2	-77,963	358.1	-106,189	332.5	-106,189	265.4	-106,189	247.1	-106,189	332.2
9	77.0	72.0	0	379.1	0	351.0	0	281.3	0	262.7	0	350.6
10	79.5	73.5	-118,598	403.8	-88,929	368.2	-88,929	300.8	-88,929	282.2	-88,929	367.8
11	82.4	74.9	0	433.7	0	407.8	0	340.1	0	321.0	0	407.4
12	85.0	76.5	-101,182	479.0	-87,225	451.2	-87,225	383.9	-87,225	364.3	-87,225	450.9
13	87.1	76.9	0	505.7	0	478.4	0	359.1	0	357.8	0	478.1
14	88.4	77.5	-92,449	541.9	-97,625	502.8	-97,625	387.1	-97,625	386.9	-97,625	502.5
15	88.9	78.0	0	553.9	0	530.2	0	412.9	0	412.8	0	529.9
16	88.4	78.2	-120,657	564.7	-130,625	525.7	-130,625	413.9	-130,625	413.9	-130,625	525.4
17	87.2	78.6	-93,778	556.9	-88,130	523.9	-88,130	412.4	-88,130	412.4	-88,130	523.6
18	85.4	78.1	-107,462	471.9	-93,007	427.5	-93,007	378.5	-93,007	378.5	-93,007	427.2
19	83.2	78.3	-117,960	407.2	-193,368	368.2	-204,066	354.6	-204,066	354.6	-204,066	368.0
20	81.0	78.5	-122,330	375.7	-99,705	336.3	-99,705	326.8	-99,705	326.8	-99,705	336.1
21	79.2	77.6	-120,058	352.4	-204,639	305.7	-204,639	303.2	-204,639	303.2	-204,639	305.5
22	77.5	76.2	-170,967	314.1	-91,840	274.8	-91,840	273.3	-91,840	273.3	-91,840	274.6
23	76.2	75.0	-148,799	291.5	-202,631	242.9	-202,631	247.5	-202,631	247.5	-202,631	242.7
24	75.2	73.9	-180,333	278.7	-86,512	232.5	-86,512	228.5	-86,512	228.5	-86,512	232.3

BUILDING COOL-HEAT DEMAND - ALTERNATIVE 1
BASELINE MODEL

September			Design		Weekday		Saturday		Sunday		Monday	
Hour	OADB	OAWB	Htg Btuh	Clg Ton	Htg Btuh	Clg Ton	Htg Btuh	Clg Ton	Htg Btuh	Clg Ton	Htg Btuh	Clg Ton
1	71.2	70.1	-212,764	204.1	0	143.7	-126,242	143.3	-96,140	143.9	-126,242	143.6
2	70.3	68.7	-93,908	185.5	-277,854	131.4	-148,150	129.0	-179,663	129.2	-148,150	128.7
3	69.6	67.5	-207,366	176.5	-14,375	124.1	-147,660	122.1	-114,745	122.2	-147,660	121.8
4	69.1	66.7	-89,264	168.2	-310,679	121.5	-172,512	118.9	-206,500	118.9	-173,135	118.7
5	68.9	66.0	-200,507	166.9	-31,850	118.0	-174,286	110.7	-140,842	110.7	-166,157	115.5
6	69.2	65.4	-85,042	212.6	-278,963	164.5	-164,056	110.6	-196,141	110.6	-153,111	164.8
7	70.1	65.6	0	282.7	-6,579	247.9	-102,954	127.7	-77,433	127.7	-99,479	248.5
8	71.7	65.4	-164,958	296.9	-98,898	266.9	-98,898	199.5	-98,898	182.5	-98,898	266.9
9	74.0	65.5	0	318.2	-33,216	278.0	0	211.8	-24,504	194.7	0	278.0
10	76.7	66.1	-109,067	342.4	-85,159	299.7	-85,159	234.9	-85,159	217.5	-85,159	299.7
11	79.7	67.7	0	372.4	0	339.1	0	273.4	0	255.3	0	339.1
12	82.5	69.9	-93,340	401.6	-90,721	362.0	-90,721	298.0	-90,721	280.0	-90,721	362.0
13	84.6	71.5	0	443.5	0	394.3	0	280.9	0	279.2	0	394.3
14	86.1	72.9	-99,472	464.7	-104,762	424.2	-104,762	311.2	-104,762	310.8	-104,762	424.2
15	86.6	73.3	0	474.6	0	429.7	0	318.9	0	318.8	0	429.7
16	86.1	73.0	-138,803	470.8	-136,315	421.1	-136,315	315.8	-136,315	315.8	-136,315	421.1
17	84.8	73.3	-98,741	457.2	-166,007	402.8	-160,862	301.6	-160,862	301.6	-160,862	402.8
18	82.9	74.8	-110,263	399.7	-93,766	345.3	-123,706	295.4	-93,766	295.4	-123,706	345.3
19	80.6	76.2	-118,124	341.9	-209,538	290.8	-175,813	279.9	-209,538	279.9	-175,813	290.8
20	78.3	76.1	-199,116	312.7	-92,127	260.6	-118,239	252.0	-92,127	252.0	-118,239	260.6
21	76.3	75.4	-110,956	288.8	-202,364	230.3	-175,888	229.6	-202,364	229.6	-175,888	230.3
22	74.6	74.3	-189,096	253.4	-81,259	204.0	-108,179	202.9	-81,259	202.9	-108,179	204.0
23	73.1	73.1	-101,495	232.8	-120,216	180.8	-92,220	186.8	-120,216	186.8	-92,220	180.8
24	72.1	71.6	-217,107	209.6	-138,555	162.8	-167,669	161.2	-138,555	161.2	-167,669	162.8

October			Design		Weekday		Saturday		Sunday		Monday	
Hour	OADB	OAWB	Htg Btuh	Clg Ton	Htg Btuh	Clg Ton	Htg Btuh	Clg Ton	Htg Btuh	Clg Ton	Htg Btuh	Clg Ton
1	58.4	55.8	-533,725	68.8	-725,340	58.3	-889,827	62.6	-731,072	62.6	-891,073	62.5
2	56.7	53.9	-727,549	60.0	-1,093,392	54.3	-927,413	55.8	-1,083,551	55.8	-928,832	55.7
3	55.3	52.7	-713,217	55.8	-964,644	52.2	-1,131,420	53.0	-977,890	53.0	-1,132,988	52.9
4	54.1	51.8	-849,679	52.8	-1,287,338	49.6	-1,116,557	50.0	-1,268,842	50.0	-1,118,109	49.9
5	53.2	51.0	-745,691	52.6	-1,099,549	49.7	-1,298,308	48.1	-1,152,156	48.1	-1,263,580	49.8
6	52.6	50.4	-671,341	73.8	-1,146,838	68.0	-1,232,914	47.5	-1,369,517	47.5	-994,260	68.1
7	52.4	50.4	-411,378	109.1	-748,266	94.9	-1,287,104	48.3	-1,195,049	48.3	-840,321	95.0
8	53.5	51.1	-317,289	117.3	-678,633	98.7	-834,033	67.6	-932,360	62.6	-705,645	98.7
9	56.5	52.9	-115,391	130.4	-621,616	107.3	-801,867	71.8	-878,015	65.4	-519,811	107.3
10	60.8	54.3	-36,467	147.4	-394,658	118.1	-544,540	75.2	-536,590	67.5	-449,902	118.0
11	65.7	57.3	-2,036	171.8	-91,898	134.1	-181,423	82.9	-178,995	73.2	-101,887	133.8
12	70.0	60.0	0	202.1	-15,353	168.9	-17,528	111.8	-18,138	97.3	-15,353	168.9
13	73.0	62.0	0	222.8	0	192.8	0	99.1	0	97.2	0	192.8
14	74.1	62.2	0	238.1	-9,546	203.2	0	109.8	-9,546	108.9	0	203.2
15	73.9	62.2	0	246.6	-87,696	206.0	0	113.3	-87,696	112.8	0	206.0
16	73.3	61.8	0	243.5	-68,261	201.6	-206,072	112.1	-68,261	111.8	-206,072	201.6
17	72.4	61.7	0	232.5	-123,855	192.8	0	105.8	-123,855	105.7	0	192.8
18	71.2	62.8	-157,004	183.7	-84,669	146.6	-232,030	100.8	-84,669	100.7	-232,030	146.6
19	69.8	64.0	0	137.2	-186,414	107.7	-20,712	99.6	-186,414	99.6	-20,712	107.7
20	68.1	63.7	-234,934	113.3	-156,982	104.1	-323,909	101.3	-153,211	101.3	-327,680	104.1
21	66.2	62.5	-98,354	94.3	-337,801	87.3	-170,225	88.6	-339,424	88.6	-168,602	87.3
22	64.2	60.9	-407,921	78.5	-334,056	82.2	-497,318	83.3	-331,103	83.3	-500,270	82.2
23	62.3	59.2	-267,449	68.3	-594,104	71.4	-413,746	75.1	-576,129	75.1	-431,721	71.4
24	60.3	57.4	-632,436	61.3	-654,512	64.9	-813,820	65.0	-653,310	65.0	-815,022	64.9

BUILDING COOL-HEAT DEMAND - ALTERNATIVE 1
BASELINE MODEL

November			------ Design -----		----- Weekday -----		----- Saturday----		------ Sunday -----		------ Monday -----	
Hour	OADB	OAWB	Htg Btuh	Clg Ton	Htg Btuh	Clg Ton	Htg Btuh	Clg Ton	Htg Btuh	Clg Ton	Htg Btuh	Clg Ton
1	56.4	54.8	-665,778	55.8	-1,145,732	53.2	-885,015	57.6	-914,067	57.7	-886,415	57.6
2	54.7	53.1	-975,526	53.1	-998,770	50.2	-1,254,004	51.9	-1,224,656	51.9	-1,255,601	51.8
3	53.3	51.8	-809,399	51.1	-1,382,354	48.5	-1,119,905	49.4	-1,149,485	49.4	-1,121,500	49.3
4	52.1	50.4	-1,082,277	48.3	-1,203,266	47.3	-1,465,509	47.7	-1,435,623	47.7	-1,467,236	47.6
5	51.2	49.7	-884,326	47.2	-1,556,191	47.1	-1,301,356	47.3	-1,331,595	47.3	-1,303,071	47.2
6	50.6	49.1	-1,045,431	46.9	-1,302,959	47.6	-1,566,760	46.1	-1,537,813	46.1	-1,535,198	47.7
7	50.5	49.0	-608,384	67.0	-1,357,620	64.4	-1,367,545	45.2	-1,394,972	45.2	-1,141,566	64.5
8	51.2	49.7	-568,120	104.9	-750,442	91.0	-1,423,079	46.0	-1,423,079	46.0	-876,922	91.0
9	53.3	50.9	-240,459	114.0	-775,424	95.5	-863,389	64.7	-962,708	59.8	-802,670	95.6
10	56.4	52.3	-108,726	125.7	-559,992	101.6	-822,871	67.7	-738,063	61.7	-486,390	101.6
11	60.0	54.1	-34,182	145.8	-455,328	113.0	-453,813	72.3	-587,357	65.0	-386,952	111.9
12	63.7	56.5	-1,920	173.7	-153,199	124.5	-411,545	76.8	-398,601	68.4	-263,446	124.5
13	66.8	58.1	0	194.3	-55,882	140.0	-89,183	88.4	-121,060	77.2	-55,882	140.0
14	68.9	59.6	0	208.5	-26,130	164.5	-50,765	72.1	-50,765	70.4	-36,072	164.5
15	69.6	60.0	0	216.0	-106,969	175.1	-24,177	80.3	-24,177	79.3	-18,792	175.1
16	69.4	60.2	-8,482	214.2	-87,318	174.3	-161,201	80.3	-161,201	79.8	-155,149	174.3
17	68.9	60.4	-157,598	201.6	-35,488	167.1	-81,735	76.8	-53,031	76.6	-66,884	167.1
18	68.0	62.1	-11,685	192.8	-285,936	176.7	-256,312	83.0	-291,803	82.8	-224,738	176.7
19	66.8	62.5	-230,397	136.8	-120,722	126.5	-191,851	82.7	-161,165	82.6	-151,407	126.5
20	65.4	62.0	-126,171	87.5	-445,521	80.5	-405,415	78.5	-435,656	78.4	-415,280	80.5
21	63.7	60.8	-438,013	75.3	-294,210	79.1	-352,232	77.2	-322,242	77.2	-324,200	79.1
22	61.9	59.5	-384,054	64.9	-697,454	69.4	-651,264	70.4	-680,946	70.4	-667,772	69.4
23	60.0	58.0	-686,293	60.4	-596,733	68.0	-623,868	68.9	-594,798	68.9	-625,803	68.0
24	58.2	56.3	-578,267	55.9	-989,561	59.7	-935,231	62.4	-964,066	62.4	-960,726	59.7

December			------ Design -----		----- Weekday -----		----- Saturday----		------ Sunday -----		------ Monday -----	
Hour	OADB	OAWB	Htg Btuh	Clg Ton	Htg Btuh	Clg Ton	Htg Btuh	Clg Ton	Htg Btuh	Clg Ton	Htg Btuh	Clg Ton
1	47.7	45.9	-1,176,115	50.3	-1,541,616	48.0	-1,735,267	48.3	-1,657,040	48.2	-1,777,015	48.1
2	46.2	44.5	-1,461,035	48.3	-1,881,858	47.5	-1,688,344	47.6	-1,777,405	47.6	-1,675,556	47.5
3	45.0	43.4	-1,335,883	47.1	-1,773,532	46.8	-1,960,151	46.8	-1,853,248	46.8	-1,934,636	46.8
4	44.3	42.7	-1,562,907	46.0	-1,984,917	46.4	-1,793,595	46.4	-1,906,649	46.4	-1,835,497	46.3
5	44.1	42.8	-1,414,694	45.2	-1,868,306	45.2	-2,058,330	45.2	-1,956,821	45.2	-2,049,727	45.2
6	44.6	43.1	-1,543,574	45.0	-1,997,324	44.9	-1,830,976	43.6	-1,911,327	43.6	-1,781,034	44.9
7	45.9	44.4	-1,098,410	61.1	-1,450,514	58.6	-1,920,915	42.2	-1,848,796	42.2	-1,669,297	58.6
8	48.0	46.5	-821,849	87.8	-1,183,199	81.3	-1,572,664	42.0	-1,646,462	42.0	-1,004,913	81.4
9	50.6	48.8	-651,368	94.8	-911,967	86.0	-1,126,957	59.0	-1,225,033	54.7	-932,042	86.2
10	53.6	51.0	-389,166	102.2	-721,747	90.2	-1,105,943	59.1	-1,101,891	54.0	-873,706	90.3
11	56.5	52.8	-256,768	111.9	-642,779	99.1	-777,272	63.9	-726,966	57.6	-574,729	99.1
12	59.1	54.3	-89,294	123.9	-471,766	109.4	-561,572	69.0	-736,887	61.5	-395,692	109.1
13	61.2	55.3	-52,280	141.0	-294,184	115.8	-419,400	71.9	-423,005	63.8	-294,184	116.2
14	62.6	56.2	-30,306	155.9	-172,429	122.2	-409,501	47.3	-436,061	46.4	-220,420	122.2
15	63.0	56.3	-24,560	163.2	-217,236	126.3	-340,628	50.0	-318,335	49.3	-169,756	126.3
16	62.8	56.2	-183,293	162.6	-198,072	128.4	-425,755	52.5	-355,263	51.9	-294,239	128.4
17	62.1	56.1	-47,707	149.4	-420,000	125.1	-546,466	52.8	-607,144	52.4	-324,095	125.1
18	61.0	56.8	-256,289	137.4	-334,274	127.6	-623,609	56.2	-540,129	55.9	-429,278	127.6
19	59.5	56.4	-291,091	96.2	-787,386	88.2	-765,702	57.8	-891,181	57.6	-678,931	88.2
20	57.7	55.1	-776,743	66.0	-772,505	59.8	-888,582	57.4	-768,721	57.2	-882,865	59.8
21	55.7	53.5	-668,914	61.1	-1,125,595	55.1	-1,044,882	53.3	-1,165,224	53.3	-1,017,076	55.1
22	53.6	51.3	-1,083,528	56.6	-1,101,152	49.5	-1,186,205	49.6	-1,066,474	49.5	-1,206,385	49.5
23	51.5	49.6	-961,996	54.1	-1,442,698	50.1	-1,348,994	50.3	-1,467,998	50.2	-1,340,916	50.1
24	49.5	47.8	-1,316,399	50.1	-1,443,686	48.8	-1,487,665	50.1	-1,369,151	50.1	-1,542,199	48.8

BUILDING TEMPERATURE PROFILES - ALTERNATIVE 1
BASELINE MODEL

------------------------------------ B U I L D I N G   T E M P E R A T U R E   P R O F I L E S ------------------------------------

Temperature Range (F)	Zone Number 1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
Max. Temp.	72.6	72.1	72.8	72.7	73.5	72.5	72.0	73.5	72.0	73.4	74.5	73.3	73.6	73.6	74.3	73.7	73.7	73.7	73.0
Mo./Hr.	6 15	5 1	6 14	8 15	6 15	5 3	1 1	6 1	1 1	6 1	6 16	9 16	4 15	4 15	6 16	6 17	6 17	6 17	6 17
Day Type	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Number of Hours																			
Above 100	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
95 - 100	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
90 - 95	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
85 - 90	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
80 - 85	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
75 - 80	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
70 - 75	8,760	8,506	7,470	8,760	8,408	8,301	8,450	8,158	8,737	8,150	8,760	8,760	8,760	8,760	8,760	8,760	8,760	8,760	8,760
65 - 70	0	254	1,290	0	352	459	310	602	23	610	0	0	0	0	0	0	0	0	0
60 - 65	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
55 - 60	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
50 - 55	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Below 50	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Min. Temp.	70.8	68.9	66.8	70.8	69.7	66.8	68.7	66.7	70.0	66.7	71.1	71.3	70.8	70.8	71.3	71.9	71.9	71.9	71.9
Mo./Hr.	1 7	1 9	1 5	1 1	1 1	2 9	1 8	1 7	2 8	1 7	2 10	1 8	1 15	1 15	1 5	1 20	1 11	1 20	1 10
Day Type	2	2	2	2	2	2	2	1	2	2	3	1	2	2	1	1	1	1	1

BUILDING TEMPERATURE PROFILES - ALTERNATIVE 1
BASELINE MODEL

------------------------------------ B U I L D I N G   T E M P E R A T U R E   P R O F I L E S ------------------------------------

Temperature Range (F)	Zone Number 20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38
Max. Temp.	73.7	73.4	73.7	72.6	73.2	72.1	73.6	72.0	73.6	72.7	72.6	73.6	72.4	72.0	72.0	72.0	72.0	72.0	72.0
Mo./Hr.	6 17	6 16	6 17	6 17	6 17	6 16	6 17	1 1	6 17	8 17	6 16	6 16	6 8	1 1	1 1	1 1	1 1	1 1	1 1
Day Type	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
	Number of Hours																		
Above 100	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
95 - 100	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
90 - 95	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
85 - 90	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
80 - 85	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
75 - 80	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
70 - 75	8,760	8,760	8,760	8,760	8,760	8,760	8,760	8,760	8,760	8,760	8,760	8,760	8,760	8,760	8,760	8,760	8,760	8,760	8,760
65 - 70	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
60 - 65	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
55 - 60	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
50 - 55	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Below 50	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Min. Temp.	71.9	71.9	71.9	71.9	71.9	71.9	71.9	71.9	71.9	71.9	71.9	71.9	71.9	71.9	71.9	71.9	71.9	71.9	71.9
Mo./Hr.	1 20	1 20	1 20	1 11	1 11	1 1	1 19	1 4	1 19	1 11	1 11	1 19	1 2	1 18	1 11	2 2	2 2	2 15	4 21
Day Type	1	1	1	1	1	1	1	1	1	1	1	1	1	2	1	1	1	2	1

BUILDING TEMPERATURE PROFILES - ALTERNATIVE 1
BASELINE MODEL

B U I L D I N G   T E M P E R A T U R E   P R O F I L E S

Temperature Range (F)	Zone Number 39	40	41	42	43	44	45	46	47	48	49	50	51	52	53	54	55	56	57
Max. Temp.	72.0	72.0	72.0	72.0	72.0	72.0	72.0	72.0	74.4	72.0	72.0	72.0	72.0	72.0	72.0	75.3	74.7	75.4	72.0
Mo./Hr.	1 1	1 1	1 1	1 1	1 1	1 2	1 2	1 1	6 18	1 1	1 1	1 1	1 1	1 1	1 1	6 17	6 18	6 18	1 1
Day Type	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Number of Hours																			
Above 100	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
95 - 100	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
90 - 95	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
85 - 90	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
80 - 85	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
75 - 80	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
70 - 75	8,760	8,760	8,760	8,760	8,760	8,760	8,760	8,760	8,760	8,760	8,760	8,760	8,760	8,760	8,760	8,760	8,760	8,760	8,760
65 - 70	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
60 - 65	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
55 - 60	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
50 - 55	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Below 50	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Min. Temp.	71.9	71.9	71.9	71.9	71.9	71.9	71.9	71.9	71.9	71.9	71.9	71.9	71.9	71.9	71.9	71.9	71.8	71.9	71.9
Mo./Hr.	4 23	1 22	1 12	1 10	2 16	1 1	1 1	2 16	1 8	1 4	1 21	1 21	1 15	1 3	1 15	1 20	1 16	1 3	1 15
Day Type	1	1	1	2	2	1	1	1	3	1	1	1	1	1	1	1	3	1	1

MONTHLY ENERGY CONSUMPTION - ALTERNATIVE 1

BASELINE MODEL

------------------------------------ M O N T H L Y   E N E R G Y   C O N S U M P T I O N ------------------------------------

Month	ELEC On Peak (kWh)	DEMAND On Peak (kW)	GAS On Peak (Therm)	WATER (1000 Gl)	GAS DMND On Peak (Thrm/hr)
Jan	445,229	802	16,459	206	35
Feb	399,481	803	15,400	183	37
March	464,572	872	9,170	270	25
April	496,435	1,029	4,243	443	13
May	535,096	1,048	3,322	618	9
June	567,035	1,056	2,744	844	6
July	591,031	1,077	2,870	923	6
Aug	604,737	1,087	2,904	966	6
Sept	536,973	1,057	2,896	709	7
Oct	473,992	878	7,126	318	22
Nov	447,031	871	8,576	264	25
Dec	447,881	825	13,262	222	32
Total	6,009,495	1,087	88,973	5,965	37

Building Energy Consumption = 148,910 (Btu/Sq Ft/Year)   Floor Area = 197,486 (Sq Ft)

Source Energy Consumption = 359,027 (Btu/Sq Ft/Year)

EQUIPMENT ENERGY CONSUMPTION - ALTERNATIVE 1
BASELINE MODEL

------------------------------------ E Q U I P M E N T   E N E R G Y   C O N S U M P T I O N ------------------------------------

Ref Num	Equip Code	Jan	Feb	Mar	Apr	May	June	July	Aug	Sep	Oct	Nov	Dec	Total
0	LIGHTS													
	ELEC	97029	87721	101425	93220	99227	97590	94858	101425	93220	99227	93168	94858	1,152,968
	PK	279.4	279.4	279.4	279.4	279.4	279.4	279.4	279.4	279.4	279.4	279.4	279.4	279.4
1	MISC LD													
	ELEC	6095	5513	6246	5890	6170	6027	6034	6246	5890	6170	5861	6034	72,176
	PK	14.7	14.7	14.7	14.7	14.7	14.7	14.7	14.7	14.7	14.7	14.7	14.7	14.7
2	MISC LD													
	GAS	0	0	0	0	0	0	0	0	0	0	0	0	0
	PK	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
3	MISC LD													
	OIL	0	0	0	0	0	0	0	0	0	0	0	0	0
	PK	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
4	MISC LD													
	P STEAM	0	0	0	0	0	0	0	0	0	0	0	0	0
	PK	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
5	MISC LD													
	P HOTH2O	0	0	0	0	0	0	0	0	0	0	0	0	0
	PK	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
6	MISC LD													
	P CHILL	0	0	0	0	0	0	0	0	0	0	0	0	0
	PK	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1		BASE UTILITY												
	ELEC	37200	33600	37200	36000	37200	36000	37200	37200	36000	37200	36000	37200	438,000
	PK	50.0	50.0	50.0	50.0	50.0	50.0	50.0	50.0	50.0	50.0	50.0	50.0	50.0
2		BASE UTILITY												
	HOTLD	1284	1160	1284	1243	1284	1243	1284	1284	1243	1284	1243	1284	15,123
	PK	1.7	1.7	1.7	1.7	1.7	1.7	1.7	1.7	1.7	1.7	1.7	1.7	1.7
1	EQ1008L	3-STG CTV >200 TONS												
	ELEC	35635	31748	45542	75875	61511	60038	66725	68388	54813	54626	45044	37962	637,905
	PK	86.7	88.3	156.5	176.6	177.5	190.3	194.6	193.8	179.4	168.6	155.0	108.7	194.6
1	EQ5100	COOLING TOWER												
	ELEC	7295	4278	12186	14317	10480	7755	8014	8014	8352	14795	13435	9854	118,775
	PK	19.9	19.9	19.9	19.9	19.9	19.9	19.9	19.9	19.9	19.9	19.9	19.9	19.9
1	EQ5100	COOLING TOWER												
	WATER	184	163	247	401	322	301	329	335	282	296	242	200	3,303
	PK	0.5	0.5	0.8	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.8	0.6	0.9

1 EQ5001 CHILLED WATER PUMP C.V.

EQUIPMENT ENERGY CONSUMPTION - ALTERNATIVE 1
BASELINE MODEL

	ELEC		36987	33407	36987	35794	26199	19388	20035	20035	20880	36987	35794	36987	359,478
	PK		49.7	49.7	49.7	49.7	49.7	49.7	49.7	49.7	49.7	49.7	49.7	49.7	49.7
1	EQ5010	CONDENSER WATER PUMP C.V.													
	ELEC		14795	13363	14795	14317	10480	7755	8014	8014	8352	14795	14317	14795	143,791
	PK		19.9	19.9	19.9	19.9	19.9	19.9	19.9	19.9	19.9	19.9	19.9	19.9	19.9
1	EQ5300	CONTROL PANEL & INTERLOCK													
	ELEC		744	672	744	720	527	390	403	403	420	744	720	744	7,231
	PK		1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
2	EQ1008L	3-STG CTV >200 TONS													
	ELEC		0	0	0	4941	45683	82744	89876	93612	67028	0	0	0	383,883
	PK		0.0	0.0	0.0	187.9	232.0	246.9	251.7	253.0	239.8	139.5	0.0	0.0	253.0
2	EQ5100	COOLING TOWER													
	ELEC		0	0	0	3480	7258	11434	12329	12901	10191	0	0	0	57,593
	PK		0.0	0.0	0.0	24.9	24.9	24.9	24.9	24.9	24.9	24.9	0.0	0.0	24.9
2	EQ5100	COOLING TOWER													
	WATER		0	0	0	20	269	461	495	512	382	0	0	0	2,139
	PK		0.0	0.0	0.0	1.2	1.4	1.4	1.4	1.4	1.4	0.9	0.0	0.0	1.4
2	EQ5001	CHILLED WATER PUMP C.V.													
	ELEC		0	0	0	5568	11613	18613	19925	20641	16306	0	0	0	92,666
	PK		0.0	0.0	0.0	39.8	39.8	39.8	39.8	39.8	39.8	39.8	0.0	0.0	39.8
2	EQ5010	CONDENSER WATER PUMP C.V.													
	ELEC		0	0	0	3480	7258	11633	12453	12901	10191	0	0	0	57,916
	PK		0.0	0.0	0.0	24.9	24.9	24.9	24.9	24.9	24.9	24.9	0.0	0.0	24.9
2	EQ5300	CONTROL PANEL & INTERLOCK													
	ELEC		0	0	0	140	292	468	501	519	410	0	0	0	2,330
	PK		0.0	0.0	0.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	0.0	0.0	1.0
3	EQ1008L	3-STG CTV >200 TONS													
	ELEC		0	0	0	0	0	34	115	0	36	0	0	0	185
	PK		0.0	0.0	0.0	0.0	0.0	35.7	37.8	0.0	33.5	0.0	0.0	0.0	37.8
3	EQ5100	COOLING TOWER													
	ELEC		0	0	0	0	1750	4057	4454	4991	2088	0	0	0	17,340
	PK		0.0	0.0	0.0	0.0	19.9	19.9	19.9	19.9	19.9	0.0	0.0	0.0	19.9
3	EQ5100	COOLING TOWER													
	WATER		0	0	0	0	4	61	77	97	22	0	0	0	261
	PK		0.0	0.0	0.0	0.0	0.3	0.7	0.8	0.8	0.4	0.0	0.0	0.0	0.8
3	EQ5001	CHILLED WATER PUMP C.V.													
	ELEC		0	0	0	0	0	0	0	0	0	0	0	0	0
	PK		0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
3	EQ5010	CONDENSER WATER PUMP C.V.													
	ELEC		0	0	0	0	0	398	616	0	99	0	0	0	1,114
	PK		0.0	0.0	0.0	0.0	0.0	19.9	19.9	19.9	19.9	19.9	0.0	0.0	19.9

EQUIPMENT ENERGY CONSUMPTION - ALTERNATIVE 1
BASELINE MODEL

	ELEC	0	0	0	0	0	20	31	0	5	0	0	0	56
	PK	0.0	0.0	0.0	0.0	0.0	1.0	1.0	1.0	1.0	1.0	0.0	0.0	1.0
1	EQ4003	FC CENTRIF. FAN C.V.												
	ELEC	7142	6451	7142	6912	7142	6912	7142	7142	6912	7142	6912	7142	84,096
	PK	9.6	9.6	9.6	9.6	9.6	9.6	9.6	9.6	9.6	9.6	9.6	9.6	9.6
1	EQ4003	FC CENTRIF. FAN C.V.												
	ELEC	2971	2683	2971	2875	2971	2875	2971	2971	2875	2971	2875	2971	34,975
	PK	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0
1	EQ4002	BI CENTRIF. FAN C.V.												
	ELEC	74	67	74	72	74	72	74	74	72	74	72	74	874
	PK	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
2	EQ4003	FC CENTRIF. FAN C.V.												
	ELEC	16740	15120	16740	16200	16740	16200	16740	16740	16200	16740	16200	16740	197,100
	PK	22.5	22.5	22.5	22.5	22.5	22.5	22.5	22.5	22.5	22.5	22.5	22.5	22.5
2	EQ4003	FC CENTRIF. FAN C.V.												
	ELEC	6963	6290	6963	6739	6963	6739	6963	6963	6739	6963	6739	6963	81,989
	PK	9.4	9.4	9.4	9.4	9.4	9.4	9.4	9.4	9.4	9.4	9.4	9.4	9.4
2	EQ4002	BI CENTRIF. FAN C.V.												
	ELEC	74	67	74	72	74	72	74	74	72	74	72	74	872
	PK	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
3	EQ4001	AIRFOIL CENTRIF. FAN C.V.												
	ELEC	25817	23318	25817	24984	25817	24984	25817	25817	24984	25817	24984	25817	303,972
	PK	34.7	34.7	34.7	34.7	34.7	34.7	34.7	34.7	34.7	34.7	34.7	34.7	34.7
3	EQ4002	BI CENTRIF. FAN C.V.												
	ELEC	296	268	296	287	296	287	296	296	287	296	287	296	3,490
	PK	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4
4	EQ4001	AIRFOIL CENTRIF. FAN C.V.												
	ELEC	23659	21370	23659	22896	23659	22896	23659	23659	22896	23659	22896	23659	278,568
	PK	31.8	31.8	31.8	31.8	31.8	31.8	31.8	31.8	31.8	31.8	31.8	31.8	31.8
5	EQ4003	FC CENTRIF. FAN C.V.												
	ELEC	20311	18346	20311	19656	20311	19656	20311	20311	19656	20311	19656	20311	239,148
	PK	27.3	27.3	27.3	27.3	27.3	27.3	27.3	27.3	27.3	27.3	27.3	27.3	27.3
5	EQ4003	FC CENTRIF. FAN C.V.												
	ELEC	9427	8515	9427	9123	9427	9123	9427	9427	9123	9427	9123	9427	111,001
	PK	12.7	12.7	12.7	12.7	12.7	12.7	12.7	12.7	12.7	12.7	12.7	12.7	12.7
5	EQ4002	BI CENTRIF. FAN C.V.												
	ELEC	2470	2231	2470	2390	2470	2390	2470	2470	2390	2470	2390	2470	29,081
	PK	3.3	3.3	3.3	3.3	3.3	3.3	3.3	3.3	3.3	3.3	3.3	3.3	3.3
6	EQ4003	FC CENTRIF. FAN C.V.												
	ELEC	7589	6854	7589	7344	7589	7344	7589	7589	7344	7589	7344	7589	89,352
	PK	10.2	10.2	10.2	10.2	10.2	10.2	10.2	10.2	10.2	10.2	10.2	10.2	10.2

6 EQ4003 FC CENTRIF. FAN C.V.

EQUIPMENT ENERGY CONSUMPTION - ALTERNATIVE 1
BASELINE MODEL

	ELEC	1785	1612	1785	1727	1785	1727	1785	1785	1727	1785	1727	1785	21,012
	PK	2.4	2.4	2.4	2.4	2.4	2.4	2.4	2.4	2.4	2.4	2.4	2.4	2.4
6	EQ4002	BI CENTRIF. FAN C.V.												
	ELEC	3494	3156	3494	3382	3494	3382	3494	3494	3382	3494	3382	3494	41,142
	PK	4.7	4.7	4.7	4.7	4.7	4.7	4.7	4.7	4.7	4.7	4.7	4.7	4.7
7	EQ4003	FC CENTRIF. FAN C.V.												
	ELEC	32066	28963	32066	31032	32066	31032	32066	32066	31032	32066	31032	32066	377,556
	PK	43.1	43.1	43.1	43.1	43.1	43.1	43.1	43.1	43.1	43.1	43.1	43.1	43.1
7	EQ4003	FC CENTRIF. FAN C.V.												
	ELEC	10025	9054	10025	9701	10025	9701	10025	10025	9701	10025	9701	10024	118,030
	PK	13.5	13.5	13.5	13.5	13.5	13.5	13.5	13.5	13.5	13.5	13.5	13.5	13.5
7	EQ4002	BI CENTRIF. FAN C.V.												
	ELEC	2805	2534	2805	2715	2805	2715	2805	2805	2715	2805	2715	2805	33,030
	PK	3.8	3.8	3.8	3.8	3.8	3.8	3.8	3.8	3.8	3.8	3.8	3.8	3.8
8	EQ4003	FC CENTRIF. FAN C.V.												
	ELEC	19344	17472	19344	18720	19344	18720	19344	19344	18720	19344	18720	19344	227,760
	PK	26.0	26.0	26.0	26.0	26.0	26.0	26.0	26.0	26.0	26.0	26.0	26.0	26.0
8	EQ4003	FC CENTRIF. FAN C.V.												
	ELEC	6016	5434	6016	5822	6016	5822	6016	6016	5822	6016	5822	6016	70,831
	PK	8.1	8.1	8.1	8.1	8.1	8.1	8.1	8.1	8.1	8.1	8.1	8.1	8.1
8	EQ4002	BI CENTRIF. FAN C.V.												
	ELEC	1695	1531	1695	1640	1695	1640	1695	1695	1640	1695	1640	1695	19,957
	PK	2.3	2.3	2.3	2.3	2.3	2.3	2.3	2.3	2.3	2.3	2.3	2.3	2.3
1	EQ2004	GAS WATER TUBE STEAM												
	GAS	16459	15400	9170	4243	3322	2744	2870	2904	2896	7126	8576	13262	88,973
	PK	34.5	36.7	25.1	13.5	8.9	5.8	5.6	5.5	6.9	22.0	24.8	31.9	36.7
1	EQ5020	HEAT WATER CIRC. PUMP C.V.												
	ELEC	1981	1789	1981	1917	1981	1917	1981	1981	1917	1981	1917	1981	23,326
	PK	2.7	2.7	2.7	2.7	2.7	2.7	2.7	2.7	2.7	2.7	2.7	2.7	2.7
1	EQ5240	BOILER FORCED DRAFT FAN												
	ELEC	4307	3890	4307	4168	4307	4168	4307	4307	4168	4307	4168	4307	50,710
	PK	5.8	5.8	5.8	5.8	5.8	5.8	5.8	5.8	5.8	5.8	5.8	5.8	5.8
1	EQ5307	BOILER CONTROLS												
	ELEC	372	336	372	360	372	360	372	372	360	372	360	372	4,380
	PK	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
1	EQ5062	CONDENSATE RETURN PUMP												
	ELEC	2024	1828	2024	1959	2024	1959	2024	2024	1959	2024	1959	2024	23,834
	PK	2.7	2.7	2.7	2.7	2.7	2.7	2.7	2.7	2.7	2.7	2.7	2.7	2.7
1	EQ5406	MAKE-UP WATER												
	WATER	22	20	22	22	22	22	22	22	22	22	22	22	263
	PK	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

2 EQ2004 GAS WATER TUBE STEAM

CALIFORNIA TITLE 24 COMPLIANCE - ALTERNATIVE 1
BASELINE MODEL

CALIFORNIA TITLE 24 COMPLIANCE REPORT

Weather Name .... MOBILE.W
Gross Conditioned Floor Area (sqft)...... 197,486
ACM Multiplier 1.025

ENERGY USE SUMMARY

	ELEC (kWh/yr)	GAS (kBtu/yr)	WATER (1000 gal)	PERCENT OF TOTAL ENERGY (%)	TOTAL SOURCE ENERGY (kBtu/yr)	ADJUSTED UNIT SOURCE ENERGY (kBtu/yr-sf)
Primary Heating	78,923.2	6,736,824.0	198.9	23.8	7,899,569.0	41.0
Primary Cooling						
Compressor	1,021,974.1	0.0	0.0	11.9	10,465,038.0	54.3
Tower/Cond Fans	193,708.0	0.0	5,702.8	2.2	1,983,574.8	10.3
Condenser Pump	202,821.0	0.0	0.0	2.4	2,076,891.6	10.8
Other Accessories	9,617.0	0.0	0.0	0.1	98,478.3	0.5
Auxiliary						
Supply Fans	2,363,839.0	0.0	0.0	27.4	24,205,768.0	125.6
Circulation Pumps	475,470.3	0.0	0.0	5.5	4,868,827.0	25.3
Base Utilities	438,000.0	0.0	0.0	5.1	4,485,130.5	23.3
Subtotal	3,277,309.2	0.0	0.0	38.0	33,559,724.0	174.2
Lighting	1,152,967.5	0.0	0.0	13.4	11,806,414.0	59.8
Receptacle	72,175.6	0.0	0.0	0.8	739,080.3	3.7
Domestic Hot Water	0.0	2,160,435.8	63.8	7.3	2,274,143.0	11.5
Cogeneration	0.0	0.0	0.0	0.0	0.0	0.0
Totals	6,009,495.5	8,897,260.0	5,965.4	100.0	70,902,912.0	366.1

UTILITY PEAK CHECKSUMS - ALTERNATIVE 1
BASELINE MODEL

--- U T I L I T Y   P E A K   C H E C K S U M S ---

Utility ELECTRIC DEMAND

Peak Value 1,087.2 (kW)
Yearly Time of Peak 10 (hr) 8 (mo)

Hour 10 Month 8

Eqp. Ref. Num.	Equipment Code Name	Equipment Description	Utility Demand (kW)	Percnt Of Tot (%)
Cooling Equipment				
1	EQ1008L	3-STG CTV >200 TONS	279.1	25.67
2	EQ1008L	3-STG CTV >200 TONS	182.5	16.79
Sub Total			461.6	42.46
Heating Equipment				
1	EQ2004	GAS WATER TUBE STEAM	11.7	1.07
Sub Total			11.7	1.07
Air Moving Equipment				
1		SUMMATION OF FAN ELECTRICAL DEMAND	13.7	1.26
2		SUMMATION OF FAN ELECTRICAL DEMAND	32.0	2.94
3		SUMMATION OF FAN ELECTRICAL DEMAND	35.1	3.23
4		SUMMATION OF FAN ELECTRICAL DEMAND	31.8	2.92
5		SUMMATION OF FAN ELECTRICAL DEMAND	43.3	3.98
6		SUMMATION OF FAN ELECTRICAL DEMAND	17.3	1.59
7		SUMMATION OF FAN ELECTRICAL DEMAND	60.3	5.55
8		SUMMATION OF FAN ELECTRICAL DEMAND	36.4	3.34
Sub Total			269.8	24.82
Sub Total			0.0	0.00
Miscellaneous				
Lights			279.4	25.69
Base Utilities			50.0	4.60
Misc Equipment			14.7	1.35
Sub Total			344.1	31.65
Grand Total			1,087.2	100.00

EQUIPMENT ENERGY CONSUMPTION - ALTERNATIVE 1
BASELINE MODEL

	GAS	0	0	0	0	0	0	0	0	0	0	0	0	0
	PK	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2	EQ5020	HEAT WATER CIRC. PUMP C.V.												
	ELEC	0	0	0	0	0	0	0	0	0	0	0	0	0
	PK	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2	EQ5240	BOILER FORCED DRAFT FAN												
	ELEC	0	0	0	0	0	0	0	0	0	0	0	0	0
	PK	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2	EQ5307	BOILER CONTROLS												
	ELEC	0	0	0	0	0	0	0	0	0	0	0	0	0
	PK	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2	EQ5062	CONDENSATE RETURN PUMP												
	ELEC	0	0	0	0	0	0	0	0	0	0	0	0	0
	PK	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2	EQ5406	MAKE-UP WATER												
	WATER	0	0	0	0	0	0	0	0	0	0	0	0	0
	PK	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0